PROCEEDINGS

of the

American Society

for

Horticultural Science

1928

Vol. 25

TWENTY-FIFTH ANNUAL MEETING

C. P. CLOSE

PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

HORTICULTURAL SCIENCE

1928

Twenty-Fifth Annual Meeting
New York City
Dec. 27, 28, and 29, 1928

Published by the Society
Edited by the Secretary, H. B. Tukey
Geneva, New York
February, 1929

CONTENTS

OFFICERS AND COMMITTEES FOR 1929

President...V. R. GARDNER

Vice-President..A. T. ERWIN

Secretary-Treasurer...H. B. TUKEY

Assistant Secretary...E. S. HABER

EXECUTIVE COMMITTEE

C. P. CLOSE, *Chairman*
E. F. PALMER
V. R. GARDNER, *President, ex-officio*
H. B. TUKEY, *Secretary, ex-officio*
H. A. JONES

NOMINATING COMMITTEE

J. R. MAGNESS, *Chairman*
H. D. HOOKER, JR.
W. A. RUTH
H. A. JONES
H. P. TRAUB

PROGRAM COMMITTEE

LAURENZ GREENE, *Chairman*
H. H. ZIMMERLEY
H. B. TUKEY

SECTIONAL GROUPS AND MEMBERSHIP

T. S. HOWLETT, *Chairman*
HENRY HARTMAN
C. L. ISBELL
W. T. MACOUN
A. F. YEAGER
V. R. BOSWELL

BOTANICAL AND BIOLOGICAL ABSTRACTS

F. C. BRADFORD
J. W. BUSHNELL

A. A. A. S. COUNCIL

W. H. ALDERMAN

NATIONAL RESEARCH COUNCIL

E. C. AUCHTER

EDITORIAL COMMITTEE

A. J. HEINICKE (1929)
H. A. JONES (1930)
F. C. BRADFORD (1931)
V. R. BOSWELL (1932)
J. R. MAGNESS (1933)

CONSTITUTION*

ARTICLE I

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held anually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, a Vice-President, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by two-thirds votes of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them. and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of three (3) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be three dollars and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

*The Constitution and By-Laws as amended from time to time.
†Since 1913 two lists of candidates have been required.

SOCIETY AFFAIRS

RESUMÉ OF THE ANNUAL MEETING AT NEW YORK CITY, DECEMBER 27, 28, AND 29, 1928

The twenty-fifth anniversary meeting was the largest in both point of attendance and number of papers presented of any meeting in the history of the Society. The attendance at the opening session was 84, and rose to 142 during other sessions. Not only were those from the East present in fullforce but also those from California, Washington, Oregon, Idaho, South Dakota, Texas, and other distant states. In short, the meeting was the most representative, best attended, and most complete that the Society has witnessed. The sessions were held in Teachers College, Columbia University. The meeting room facilities were thoroughly satisfactory, adding materially to the comfort and convenience of those present.

Although there were literally 101 items of business on the program, it was well handled and completed with little difficulty. The plan begun a year ago in which an individual was designated to lead the discussion for groups of similar papers, was again followed and proved very helpful. The trend of thought among scientific workers may be gathered by a comparison of the programs for the last few years. This year it was necessary to provide two separate sessions for papers dealing with vegetables, and one afternoon was devoted largely to propagation problems.

The next meeting will be held at Des Moines, Iowa.

DINNER AND SOCIAL EVENING

Departing from the procedure of former years, the president's address was the feature of the dinner and social evening. Unfortunately, with the insistence that the evening be cut short so as to allow members to participate in the festivities of the Great White Way, the social side was necessarily curtailed. Nevertheless, the plan of having the president deliver his address at the banquet was well received.

With Dr. V. R. Gardner as toastmaster, Dr. E. C. Auchter was called upon for a few remarks, after which brief obituaries were given by Dr. W. P. Duruz and Professor C. P. Close for two members who had died during the year, namely, Dr. J. T. Rosa, Jr., and Professor C. W. Mathews.

ITEMS OF BUSINESS

Cooperation with National Association of Gardeners

It was voted to accept the invitation of the National Association of Gardeners, 522 Fifth Avenue, New York City, to cooperate in the movement for plant registration. The incoming president was instructed to appoint a committee of three to act for the Society.

Length of Program

Following a discussion with regard to the advisability of extending the annual meetings to four days, it was voted to leave this matter in the hands of the Program Committee, with authority to arrange for four days, if necessary.

Prices of Back Reports

It was voted to charge $3.50, postage extra, for all back reports of the Society, excepting that members of the Society may purchase reports, postpaid, at a price equal to the annual dues for the year which the reports represent.

Election of Officers

In its report the nominating committee presented the names of V. R. Gardner and G. F. Potter to ballot upon for the nomination of president. The ballot resulted in the nomination of V. R. Gardner. The secretary was then instructed to cast the vote of the Society in favor of the officers and committees shown on page 7 of these Proceedings.

Audit of Society Records

The auditing committee reported that it had examined the accounts of the treasurer and found them correct.

C. G. Woodbury
W. W. Robbins
C. K. Burkholder
Committee

Resolutions

Resolved, That the thanks of the members of the Society be extended to the Program Committee for the excellent program provided for the meeting.

Resolved, That the Committee of Columbia University, which has furnished such satisfactory accommodations for the sessions of the Society, be informed of the appreciation of the members, and be duly thanked for their consideration and courtesy.

Resolved, That the thanks of the members of the Society be expressed to the officers of the Society for their efficient services during the year and the great delight of the members at the present financial condition of the Society.

Resolved, That messages of sympathy be sent to the wife or nearest relative of those members who died during the past year.

W. T. Macoun
F. S. Howlett
Committee

TREASURER'S REPORT FOR 1928

Receipts

Dues collected during 1928	$1,415.00	
Reports sold during 1928	830.00	
		$2,245.00
Balance on hand Jan. 1, 1928		776.69
		$3,021.69

Expenditures

Jan. 1	V. R. Gardner, mimeographing abstracts	$ 13.00
Jan. 1	Telegram L. H. Bailey	.60
Jan. 2	Stamps	2.00
Jan. 18	Rose Glaspey, stenographic services	2.00
Jan. 18	Susan McLaughlin, stenographic services	3.00
Jan. 18	Mimeographing circular letter	.50
Jan. 18	George Boyer, hauling	1.00
Jan. 18	Stamps	3.00
Jan. 24	Stamps	1.00
Jan. 21	Lehigh Valley Ry	5.33
Jan. 31	M. F. Devaney—rubber stamp	1.60
Feb. 11	Postmaster, 1000 stamped envelopes	22.62
Feb. 21	W. F. Humphrey—envelopes, letterheads, bills, etc	23.25
Mar. 1	Mary Fahy, stenographic services	5.50
Mar. 27	Postmaster, Geneva, stamps, 1927 Reports	49.35
Mar. 30	Secretary's fees for 1928	250.00
Apr. 2	Mary Fahy, stenographic services	4.25
Apr. 5	Anna Mosey, stenographic services mailing 1927 Report	10.00
Apr. 17	W. F. Humphrey, Geneva, N. Y., printing 1927 Proceedings	844.77
May 11	Geneva Trust Co., printing checkbook	1.22
May 15	Stamps—1927 Report	15.48
May 31	Mary Fahy, stenographic services	5.05
June 15	Stamps—mailing reports, etc	10.00
June 16	Anna Mosey—indexing	7.20

July 10	Postmaster, 1000 stamped envelopes	22.62	
July 20	Refund to Hort. Soc. Gardens, Wisley, England on report	2.50	
Oct. 8	Stamps	10.00	
Nov. 14	W. F. Humphrey, 1000 bills	4.50	
Dec. 1	Stamps—mailing reports, etc	14.16	
	Total expenditures	$1,335.50	
	Balance on hand December 1, 1928	1,686.19	
			$3,021.69

Respectfully submitted,
H. B. TUKEY, *Treasurer*

Audited and found correct,
C. G. WOODBURY
W. W. ROBBINS
C. L. BURKHOLDER
Committee

Further Studies on Sex in Asparagus

W. W. Robbins and H. A. Jones, *University of California, Davis, Calif.*

IN 1926, the authors presented data which tended to show characteristic differences between male and female asparagus plants. Since that time, two years of additional data have been secured which show that these differences are consistent.

In 1923, a large number of male and female asparagus plants were labelled in the nursery at the University Farm, Davis, California. These crowns were set early in 1924 in separate rows in the permanent bed. The rows are 240 feet long and 7.5 feet apart. Corresponding staminate and pistillate rows were placed side by side. From this planting, there is now a record of the top growth made in the five years 1924 to 1928, and of spear production for four years, 1925 to 1928. The data are summarized in tables I and II in terms of average per plant.*

TABLE I—A Comparison of the Size, Number and Yield of Spears from Staminate and Pistillate Asparagus Plants

Year	Last Harvesting Date	Ave. Number Spears per Plant		Ave. Weight Spears per Plant in Grams		Ave. Weight per Spear in Grams		Yield per Acre in lbs.	
		Staminate	Pistillate	Staminate	Pistillate	Staminate	Pistillate	Staminate	Pistillate
1925...	April 1	3.0	2.0	55.0	40.4	18.1	19.9	372	278
1926...	April 25	16.6	9.4	377.9	216.3	22.8	26.5	2407	1576
1927...	May 15	24.5	14.9	626.4	466.9	25.5	31.3	3989	2949
1928...	May 15	26.4	18.5	758.3	611.5	25.6	33.0	4819	3864

TABLE II—A Comparison of the Yield of Stalks from Staminate and Pistillate Asparagus Plants

Year	Average Number of Stalks per Plant		Average Weight of Stalks per Plant in Pounds	
	Staminate	Pistillate	Staminate	Pistillate
1924........	10.5	5.7	0.8	0.7
1925........	9.4	5.6	2.8	2.3
1926........	9.4	5.1	3.2	2.5
1927........	9.3	5.0	3.2	2.5
1928........	10.7	6.7	3.6	3.0

The staminate plants produce a larger number and a greater weight of stalks than the pistillate plants. They also produce more spears per plant and a higher yield per acre, but the average size of the spears is somewhat smaller. The differences between the sexes have been consistent thus far. It is planned to carry on these studies at least for a period of ten or twelve years.

The greater average weight of single spears of pistillate plants as compared with staminate raised the question as to whether pistillate plants might not be more desirable commercially in spite of the lower

*Throughout this paper, the averages are for staminate rows, 1, 3, 31, 33, 61, and 63, and for pistillate rows, 2, 4, 32, 34, 62, and 64.

total yield per acre. Accordingly, during the seasons of 1927 and 1928, each day's cutting from certain staminate and pistillate rows was graded. The sizes of the five grades used were: below ⅜ inch, ⅜ to ½, ½ to ⅝, ⅝ to ¾, and over ¾ inch. The weight of spears falling into each grade was ascertained. The diameter was taken about 5½ inches from the tip. The results for 1928 are given in Table III.

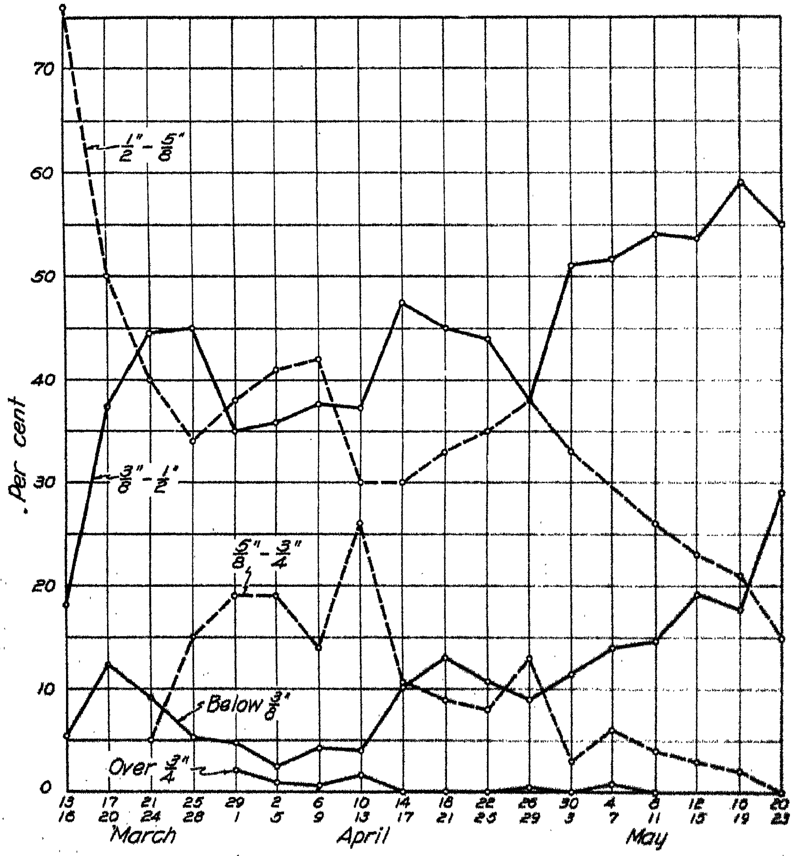


FIG. 1. Percentage of different grades of asparagus throughout the cutting season of 1928. Staminate plants.

This table shows that only in the two smallest grades does the total weight of spears from staminate plants exceed that from pistillate. As all the spears below ⅜ inch are discarded, a least in canning, it its seen that from the staminate plants approximately 13 per cent by weight of the total harvest must be discarded, whereas in the case of pistillate plants this amounts to but 4 per cent. Spears over ¾ inch in diameter constitute a very small part of the total yield. The total weight per acre of spears above ⅜ inch from staminate plants is 4107.8 pounds; the total weight of spears from pistillate plants of these same grades is 3628.4 pounds.

TABLE III—TOTAL YIELD AND THE PER CENT OF THE TOTAL YIELD FALLING IN EACH GRADE. STAMINATE AND PISTILLATE PLANTS
VARIETY PALMETTO, YEAR 1928

Sex	Below 3/8″		3/8″ to 1/2″		1/2″ to 5/8″		5/8″ to 3/4″		Over 3/4″		Total
	Pounds per Acre	Per cent	Pounds per Acre	Per cent	Pounds per Acre	Per cent	Pounds per Acre	Per cent	Pounds per Acre	Per cent	Yield Pounds
Staminate...........	625.9	13.4	2226.5	47.0	1441.5	30.4	424.7	8.9	15.1	0.3	4733.6
Pistillate...........	156.6	4.4	1135.9	30.0	1513.3	39.9	851.5	22.4	127.7	3.4	3793.9

In the California Delta, green asparagus is cut, as a rule, up to about April 1, after which most of the fields are cut white. In 1928 up to the first of April, 652.4 pounds per acre of green asparagus were harvested from staminate plants, and 385.5 pounds per acre from pistillate plants.

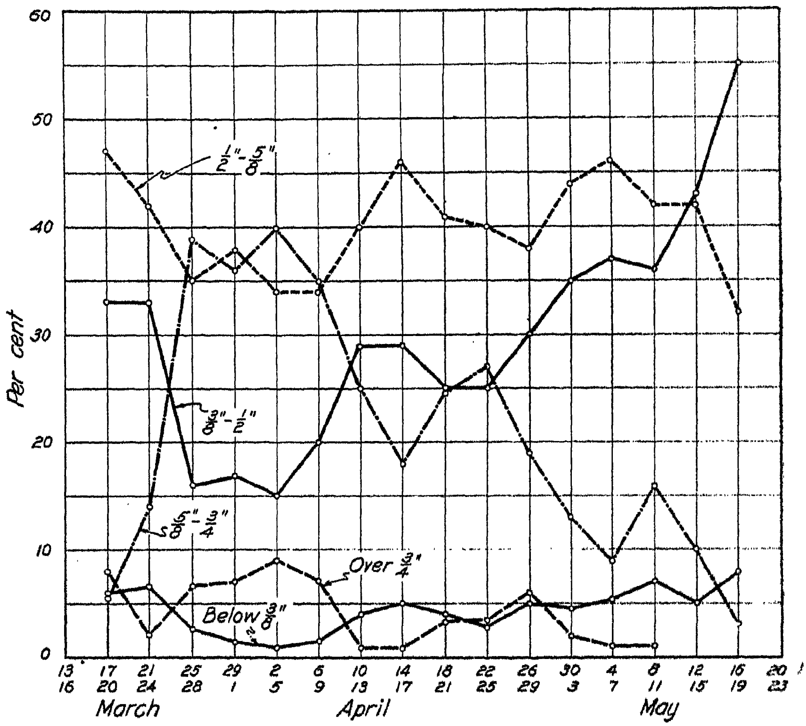


FIG. 2. Percentages of different grades of asparagus throughout the cutting season of 1928. Pistillate plants.

The percentages of the various grades at different times throughout the cutting season are shown in Figs. 1 and 2. It will be seen from these that the percentage of the smallest grade (below 3/8 inch) is higher in the case of staminate plants than in pistillate, and increases more rapidly during the cutting season; grade 3/8 to 1/2 inch describes about the same curve for both male and female plants, although the percentages are generally somewhat higher for the male plants; with grade 1/2 to 5/8 inch the per cent is very high at the beginning of the season for both sexes, but falls off in both cases during the season, and particularly rapidly in the male plants; with grade 5/8 to 3/4 inch for both sexes, the percentage is relatively low at the beginning of the season, reaches a maximum after a few weeks, and then decreases; grade over 3/4 inch, with both sexes, is somewhat higher in the early part of the cutting season than later.

Studies of Tomato Quality. III Color of Different Regions of a Tomato Fruit and a Method for Color Determination

By JOHN H. MACGILLIVRAY, *Purdue University, Lafayette, Indiana*

TOMATO color* is one of the most important factors influencing quality. In this study the first method used to determine tomato color involved the extraction of the pigments by means of alcohol and the use of a colorimeter to compare the pigments which had been transferred to a carbon bisulfide solution (2). The complete extraction of the pigments was slow, and there was no suitable color standard available. Objections were offered to the use of a chemical method for the determination of a physical characteristic. After the discarding of this procedure, the following instruments were considered for their effectiveness in determining tomato color: Guild Trichromatic Colorimeter, Ives Tint Photometer, Keuffel and Esser Color Analyzer, Lovibond Tintometer, and Munsell Color System. The Munsell Color System was selected after the color of good, medium, and poor samples of tomato pulp had been determined on these various instruments.

The Munsell Color System specifies color by means of three dimensions or attributes, namely, value, hue, and chroma, as follows:

"*Value* (or Brilliance) is that attribute of any color in respect of which it may be classed as equivalent to some member of a series of grays ranging between black and white" (7).

"*Hue* is that attribute of certain colors in respect of which they differ characteristically from the gray of the same brilliance (or value) and which permits them to be classed as reddish, yellowish, greenish, or bluish" (7).

"*Chroma* (or Saturation) is that attribute of all colors possessing a hue, which determines their degree of difference from a gray of the same brilliance" (7).

The Munsell System is explained most clearly by aid of a "Color Sphere" in which the hues are arranged on the circumference of a circle perpendicular to the polar axis of the sphere, and the polar axis represents values of colors from dark to light. Red (hue) may be light or dark (value), and weak or strong (chroma). Chroma the third dimension of the color sphere, extends outward along the radius. A chroma is gray at the central axis and as the chroma extends farther outward on the radii, away from the central axis, it becomes stronger in color and less gray. Colors differ by nature in their Chroma strength, some being much more powerful than others, and consequently the so-called color sphere is irregular in shape.

*Acknowledgment is due Miss Dorothy Nickerson, Bureau of Agricultural Economics, U. S. D. A., for explanation and instruction in the Munsell Color System as well as many helpful suggestions in regard to equipment.

Value, hue, and chroma are each divided into units for specifying color. The hue circle contains 100 steps equal to the eye, in which red is designated as 5, yellow red as 15, yellow as 25, etc. Value is noted on a scale of 0 to 10, or black to white. Chroma may have a varying number of equal steps depending upon the hue, 0 indicating neutral and 10 a strong chroma. Thus a Munsell Notation of 5R 4/10 indicates the hue is 5 red, value is 4, and the chroma is 10. At the present time it seems that a desirable tomato color would possess a low hue, strong chroma, and a dark value (such as 5R 2/11). The desirability of tomato color can be told in most cases from the hue reading alone.

The Munsell Notation for any color is determined by means of matching the sample with different areas of colored discs. It is possible to expose varying areas of these discs and obtain a uniform color for matching by rotating on an electric motor. If with one set of areas the match is not correct then the areas may be changed until the correct match is obtained. Since each disc is provided with the correct Munsell Color Notation it is possible to calculate value, hue, and chroma by means of proper formulae (5) which depend upon the areas of discs exposed and the notation of the discs used. A Bausch and Lomb Special Optical Mount is very helpful in making the readings as it brings into juxtaposition within an eyepiece the color from the discs and the sample. It is important to know the color sensitivity of any persons who match colors, since obviously a color blind person cannot match colors successfully. Bad cases may be identified by reference to one or two very simple tests (3, 6). For a detailed explanation of the Munsell Color System reference may be made to an article by T. M. Cleland (1).

The regions of a tomato fruit were separated according to the usual method (4). The samples were pulped in a potato ricer. The pulp was placed in a tin can one inch in height for color matching. All determinations were made in the light from a north window between 10 A.M. and 3 P.M. on sunny days. The total solids of these samples did not vary sufficiently to affect the color interpretations.

Discussion

The outer and inner wall region of a tomato fruit possesses the best red color (Table I). In other tomato work at this Station, the outer and inner wall region has been shown to be more valuable from the standpoint of quality for the following reasons: It has a higher percentage of dry matter, a higher percentage of insoluble solids, and a sweeter taste. The tomatoes were picked for ripeness according to color, and no conclusions are drawn as to the best colored varieties. The Marglobe tomatoes (Table I, 8/1/1928) were very ripe and hence it was difficult to separate all the regions. This sample gave the smallest difference in Hue between the different regions. Evidently the ripest fruits possess not only the best color in the outer and inner wall, but the different regions vary less in color.

The data in Table II are presented as evidence that partially ripe tomatoes greatly affect the color of tomato pulp. Many tomatoes

TABLE I—COLOR OF DIFFERENT REGIONS OF TOMATO FRUITS

	John Baer 7/10/1928			Marglobe 8/1/1928			Marglobe 8/6/1928			Indiana Baltimore 8/6/1928			Red Rock 8/7/1928		
	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma
Outer and Inner Wall.	7.97	3.04	7.32	5.0	2.47	11.15	5.05	2.48	9.85	6.30	2.69	9.16	5.32	2.72	10.67
Inner Locule Tissue.......	9.76	3.13	5.82	*			7.15	2.98	9.74	9.06	3.12	7.15	7.74	3.38	10.84
Jelly-like Pulp......	11.70	3.05	4.87	5.84	2.60	10.28	7.90	2.71	7.59	8.82	2.84	7.20	8.18	2.72	7.37

*Fruit very ripe unable to separate Inner Locule Tissue and Jelly-like Pulp.

TABLE II—COLOR OF RIPE AND PARTIALLY RIPE TOMATOES

	John Baer 7/19/1928			Greenhouse Bonny Best 7/23/1928			Marglobe 7/24/1928			Indiana Baltimore 7/25/1928			John Baer 7/28/1928		
	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma	Hue	Value	Chroma
Red Ripe	5.73	2.67	11.46	5.78	2.78	10.51	5.71	2.98	11.17	5.81	2.88	10.68	5.0	2.50	10.73
Two-thirds Red Ripe..	8.02	3.26	9.26	11.04	3.25	5.32	7.93	3.25	8.66	8.30	3.22	8.61	7.22	3.04	9.31
One-third Red Ripe..													11.18	3.35	5.59

are used in canning factories that are only two-thirds red ripe. For a canner to obtain a good colored product he must use tomatoes which are wholly red but have not started to decay. This period of development will necessarily be very short. As long as tomatoes are used in the manufacture of pulp which have as great a variation in Hue as found in Table II, there is little need to look for better colored varieties. Color determinations on 32 samples of pulp gave an average Hue of 8.70. The best Hue was 6.26 and the poorest 10.4. These samples were selected so as to provide the best and poorest colored pulp.

In Table II the data indicate that the raw stock may be obtained 5.00 R in hue or very much better than any sample of pulp obtained. Consequently there is a large difference in color between the best raw product and the best pulp. The reason for this difference is unknown. It may be due to factory methods or a small number of partially ripe tomatoes. The samples in these tables were not all of the same degree of ripeness, the ripest tomatoes possessed color of approximately 5. R in hue.

Literature Cited

1. Cleland, T. M. A practical description of the Munsell color system with suggestions for its use. Munsell Color Company, Baltimore, Maryland. 1921.
2. Howard, Grace E. Pigment studies with special reference to carotinoids of fruits. Annals Mo. Bot. Garden, 12:145–213. 1925.
3. Ishihara, S. Tests for color-blindness. Published in Japan. American Agents, C. H. Sketting Company, Chicago, Illinois.
4. MacGillivray, John H. Effect of phosphorus on the composition of the tomato plant. Jour. of Agr. Res., 34:97–127. 1927.
5. Nickerson, Dorothy. Color discs in soil analysis. Science N. S., 68:304–305. 1928.
6. Stilling, Pseudo-isochromatic plates for testing color sense. E. B. Meysoivitz, Inc., New York City. 1922.
7. Troland, L. T., et al. Report of the colorimetry committee of the Optical Society of America, 1920–21. Jour. of the Optical Soc. of Amer. and Rev. of Sci. Instruments, 6:527–596. 1922.

Temperature Influence upon Chemical Composition and Quality of Peas (Pisum Sativum, L.)

VICTOR R. BOSWELL, *University of Maryland, College Park, Maryland*

INTRODUCTION

THERE is a prevailing opinion that peas which mature relatively late as a result of late sowing, are inherently of a lower quality than those of the same variety which have made their growth and which mature earlier during cooler weather. Many canners and growers believe that the high temperatures under which late sown and late maturing peas must develop cause the peas to be harder, more starchy, and of lower quality than early maturing peas which are harvested at apparently the same stage of maturity. The present studies were carried on to determine if such effects really exist.

EXPERIMENTAL METHODS

In 1925 a commercial stock of the Alaska variety was used which was so variable as to cause doubt of validity of the results. In 1927 and 1928 a particularly uniform strain of the same variety was secured from the breeding stocks of the Everett B. Clark Seed Co., Milford, Conn. and The Associated Seed Growers, Inc., New Haven, Conn. respectively.*

The methods of growing and harvesting the different series of plantings were essentially the same as described by the writer in a previous report before this Society (3).

Two harvests were made in most cases, the first at a very early canning stage, and the second at a normal canning stage. The early harvest was made in order to secure an additional number of readings and to observe differences in a given size of pea secured on different dates. The entire plant was harvested in each case, and all pods which contained peas of No. 1 size or larger were removed for shelling.

After numbers and weights of vines and pods had been secured for other purposes (3) the peas were shelled by hand, graded through a small set of standard pea sieves, and each grade was weighed. Replicates were then combined according to grade and mixed thoroughly. Fifty-gram samples were with-drawn, killed, and preserved in alcohol for analysis (2).

After a period of 3 to 13 months, the storage alcohol was decanted from the sample, the residue dried at 70 degrees C. and ground to pass a 60-mesh sieve; suitable aliquots were extracted in a Soxhlet apparatus with alcohol for three hours. From this point the analytical procedure was essentially the same as previously described (2) for dry matter, total sugars, acid hydrolyzable substances, starch, alcohol insoluble nitrogen, and total nitrogen.

Temperature summations above 40 degrees F. and mean temperatures were derived from charts from a thermograph located on the

*The writer gratefully acknowledges the interest and helpfulness of the seedsmen who made available this closely selected stock.

TABLE I—SUGAR AND STARCH CONTENT OF DIFFERENT GRADES OF PEAS HARVESTED FROM SUCCESSIVE PLANTINGS ON DIFFERENT DATES. EXPRESSED AS PERCENT OF FRESH WEIGHT

Date of Planting	First Harvest							Second Harvest						
	Date of Harvest	Dry Matter		Sucrose		Starch		Date of Harvest	Dry Matter		Sucrose		Starch	
		No. 2	No. 3	No. 2	No. 3	No. 2	No. 3		No. 2	No. 3	No. 2	No. 3	No. 2	No. 3
	Season of 1925							Season of 1925						
3/28	6/8	42.34	39.53	4.29	2.97	12.52	12.99	6/13	40.76	41.96	3.70	3.70	14.29	14.80
4/2	6/9	34.13	38.31	2.56?	2.80	10.85	12.33	6/17	39.56	42.86	3.38	3.23	12.90	15.30
4/8	6/10	34.97	37.49	3.15	2.93	10.85	12.20	6/18	36.99	41.35	2.88	2.57	13.05	14.01
4/15	6/11	33.46	35.67	3.80	3.58	10.13	11.65	6/19	37.26	41.25	2.88	2.63	12.33	13.99
4/23	6/15	28.66	34.75	4.28	3.80	8.09	11.37	6/18	28.97	37.02	3.58	2.93	8.50	11.84
	Season of 1927							Season of 1927						
3/18	6/9	24.86	29.15	3.85	3.24	5.84	8.45	6/14	28.95	33.64	2.58	2.33	8.30	11.02
3/28	6/10	23.82	27.98	4.13	3.62	5.58	7.71	6/16	30.59	35.48	2.17	1.77	8.48	11.62
4/8	6/15	22.62	27.58	3.17	2.35	5.83	8.52	6/21	32.46	—	2.40	—	10.08	—
4/18	6/18	23.38	27.47	4.25	3.94	5.28	7.52	6/23	29.22	—	3.35	—	8.39	—
4/29	6/22	23.22	26.96	4.29	3.87	3.96	7.31	6/27	29.15	33.19	3.33	2.78	8.64	10.52
5/9	6/27	24.82	26.46	5.19	4.50	4.90	6.08	—	—	—	—	—	—	—
	Season of 1928							Season of 1928						
3/24	6/4	22.28	24.60	4.99	4.31	4.00	5.49	6/11	24.62	29.96	4.21	3.68	5.69	9.51
4/7	6/12	21.36	25.40	4.39	3.61	4.23	6.48	6/16	26.52	32.02	4.00	3.55	6.46	10.16
4/24	6/19	22.38	26.58	4.84	4.12	4.98	6.89	6/24	27.90	33.56	3.39	2.59	7.86	10.95
5/7	6/23	24.04	26.97	4.27	3.67	5.60	7.86	6/27	29.78	33.95	2.91	2.67	9.25	10.72
Mean		27.10	30.32	4.09	3.55	6.77	8.86		30.91	36.35	3.20	2.87	9.59	12.03

plots where the peas were grown. The calculations were made from accurate planimeter measurements.

Presentation of Results

In this brief space yields must be disregarded and the problem stated above must be closely adhered to. Complete details and discussion of the methods and results will be published elsewhere at a later date.

Abundant evidence shows that chemical composition is a good index to the table quality of many horticultural products. Appleman (1) has emphasized the importance of the starch-sugar ratio in relation to flavor of sweet corn. Work by the writer (2) indicates that this relationship also holds for peas. Quality and flavor vary inversely to the starch-sugar ratio; therefore, particular attention is here directed to this factor as an index to quality. The ratios of soluble-insoluble nitrogen were also examined as possible indicators of maturity, but since the results parallel those of the starch-sugar ratios so closely, they will not be discussed.

A preliminary study of the results showed a wide variation in the several constituents and ratios which were considered as possible indices of quality. It was hoped that this troublesome variation could be accounted for on the basis of apparent stage of maturity at which the peas were harvested. As an attempt to express or describe the stage of maturity by a single numerical term, a "maturity index" was devised as follows: each grade was given a weighting, corresponding for convenience, to the number of the grade. The percent of peas in each grade was multiplied by its assigned weighting, and the sum of all products for a single harvest was taken as the maturity index. The higher the index value, the more nearly mature were the peas when harvested, if maturity be judged on the basis of size distribution.

The analytical results most pertinent to the question are presented in Table I. The starch-sugar ratios, together with the temperature summations, mean-temperatures and maturity indices are summarized in Table II.

Discussion

A study of the starch-sugar ratios in Table II shows no definite and consistent direction of change through the three different harvest seasons. In the series of first harvests in 1925 the ratios increased for the first two or three harvests and then decreased, indicating that the earlier and later plots yielded a higher quality product than the intermediate ones. The latest plot yielded the lowest ratio. In 1927 a similar situation was found, but in 1928 the ratios consistently increased from the earliest to the latest plot.

When these facts were first observed, it was believed that faulty judgment in estimating similar stages of development at harvest had resulted in wide divergences of the distribution in sizes of peas secured. If the different plots had been harvested at stages of development which were not even apparently similar, one might expect considerable variation in the composition of a certain size of pea,

although size is most commonly accepted as an index of stage of development and quality. "Maturity indices" were calculated to give at a glance a picture of the stage of development as commonly judged by size. Some variations in size distribution existed, but in most cases they were small within any one series of harvests. It is easily seen by inspection (Table II) that the starch-sugar ratios are not correlated with the maturity indices within one series of harvests. This indicates that the various plots were harvested at similar stages of development, as accurately as can be determined by the eye and by mechanical measurement, and that the existing variations of ratios within a series are due to factors other than faulty estimation of the harvest stage.

The effect of temperature upon the starch-sugar relations of the storage tissues of plants is well known. The very harmful influence of high temperature upon the growth and yield of the pea, and its effect on the rate of development, has been pointed out by the writer (3). Were temperature variations responsible for the inconsistent behavior of the starch-sugar ratios in the different years? In Table II are given the mean temperatures and the heat summations in hour-degrees above 40 degrees F. from blossoming to harvest of each planting. No consistent relationship can be noted between mean temperature and chemical composition, but there is a very good correlation between temperature summations and starch-sugar ratio. For Grade No. 2, the coefficient of correlation is $+.739.\pm 055$ and for the No. 3's it is $+.805\pm.045$ over a period of three years. Thus, even though a high mean temperature may prove especially disastrous to yields, as has been previously established, it does not necessarily, *per se*, damage the quality of the product by producing a high starch-sugar ratio at the apparently proper harvest stage.

Note in Table II that in 1925 and in 1927, as the mean temperature increased the ratios tended to decrease, and that the fluctuations are closely correlated with the temperature summations. In 1928 the ratios happened to increase with the mean temperatures, but that was most probably only a chance parallelism, since the ratios were again positively correlated with the temperature summations. There are slight increases in ratio for the later plantings in 1928, but in the other two years the ratios decreased for those peas from successively later plantings. In the one year in which ratios increased, the increases were slight even though the spread in planting dates was greatly exaggerated for effect. For successive plantings within a fair range of planting dates in any one year, there appears to be little danger of an inherently poor quality product from the later plantings; in fact, the opposite seems to be more probable.

Data are not at hand by which we can explain the radical differences in relation between temperature summation and a given stage of maturity in different years. Strain differences may account, in part, for the higher ratios and summations in 1925, but the last two years' work was done with one strain, and still rather divergent results were obtained. It is believed that nutritional conditions which affect the rate of growth and development play an important

TABLE II—STARCH-SUGAR RATIOS OF PEAS HARVESTED FROM SUCCESSIVE PLANTINGS UPON DIFFERENT DATES.

Date of Planting	First Harvest						Second Harvest					
	Date of Harvest	Temperature*		Sugar-Starch Ratio		Maturity Index	Date of Harvest	Temperature*		Sugar-Starch Ratio		Maturity Index
		Summation Hour Degrees	Mean Degrees F	No. 2	No. 3			Summation Hour Degrees	Mean Degrees F	No. 2	No. 3	
	Season of 1925						Season of 1925					
3/28	6/8	18,988	68.25	2.92	4.38	241	6/13	23,072	69.13	3.86	4.00	205
4/2	6/9	19,011	69.34	4.24?	4.40	233	6/17	26,117	71.09	3.81	4.74	221
4/8	6/10	17,649	70.64	3.44	4.16	243	6/18	24,801	72.30	4.53	5.45	230
4/15	6/11	14,857	72.58	2.66	3.25	234	6/19	22,291	74.40	4.28	5.32	221
4/23	6/15	15,735	76.42	1.89	2.99	273	6/18	18,601	76.00	2.37	4.04	267
	Season of 1927						Season of 1927					
3/18	6/9	15,378	62.09	1.52	2.61	231	6/14	19,103	63.40	3.22	4.73	317
3/28	6/10	14,243	62.82	1.35	2.13	213	6/16	18,116–	63.58	3.91	6.57	279
4/8	6/15	16,533	65.51	1.84	3.63	237	6/21	20,037	65.39	4.20	—	351
4/18	6/18	14,838	64.73	1.24	1.91	228	6/23	18,420	65.59	2.50	—	323
4/29	6/22	13,384	64.24	.92	1.89	216	6/27	17,146	66.45	2.59	3.78	309
5/9	6/27	12,464	68.85	.94	1.33	218	—	—	—	—	—	—
	Season of 1928						Season of 1928					
3/24	6/4	12,178	63.06	.80	1.28	245	6/11	16,810	64.15	1.35	2.58	330
4/7	6/12	13,260	64.02	.96	1.80	281	6/16	16,319	65.17	1.62	2.86	327
4/24	6/19	14,215	66.92	1.03	1.67	276	6/24	16,914	69.37	2.32	4.23	330
5/7	6/23	12,068	67.94	1.31	2.14	249	6/27	15,329	69.03	3.18	4.02	321

*From blossoming to harvest.

part. At present, however, the complicated inter-play of temperature, soil nutrients, inherent characteristics of different strains, and probably also length of day, is so little understood that no explanation can be offered.

Although it appears that delayed maturity causes no inherent decrease in the quality of a certain grade of pea when the peas are harvested at the proper time, it is clear that delaying harvest beyond the proper point results in a loss of quality in two ways; first, a less desirable distribution of sizes of peas; and second, a decrease in the quality of each size secured. It is felt that this latter point accounts for the belief that late-maturing peas are harder and less desirable than early maturing peas. Under high temperature, the crop approaches maturity so rapidly that although harvest is begun at the proper stage of development, the peas often will have passed far beyond that point before the harvesting of a large acreage can be completed. Unexpectedly high temperatures which may occur in the later part of the harvest season make prediction of harvest dates difficult, often with serious loss to the canner.

Conclusions

1. Late maturity resulting from late planting of Alaska peas does not result in an inherently lower quality of product if the crop is harvested at the evidently proper stage of maturity.

2. The low quality product often secured from late-maturing plantings is probably the result of such a rapid rate of maturity under high temperature conditions that the crop can not be (or is not) harvested at the stage at which it should be. A practiced eye can note the proper stage with reasonable accuracy and uniformity.

3. Even though late planting appears to have no very harmful effect upon quality, it should be borne in mind that it materially reduces yields, in most seasons.

Acknowledgment

The writer expresses his appreciation of the assistance of Mr. Howard B. Cordner, who made part of the chemical analyses reported in this paper.

Literature Cited

1. Appleman, C. O., and Eaton, S. V. Evaluation of climatic temperature efficiency for the ripening process in sweet corn. Jour. Agr. Res., 20:795–805. 1921.
2. Boswell, V. R. Chemical changes during growth and ripening of pea seeds. Proc. Amer. Soc. Hort. Sci., 178–187. 1924.
3. ———. The influence of temperature upon the growth and yield of garden peas. Proc. Amer. Soc. Hort. Sci., 162–168. 1926.

Heat Injury to Early Potatoes at Harvest Time

By HARRY JENSEN, *Washington Irrigation Branch Station, Prosser, Washington*

HARVESTING time for early potatoes comes as a rule during extremely hot weather and the growers face a serious problem of preventing the exposure of the tubers to excessive heat during harvesting operations. Numerous cases are on record of apparently sound potatoes decaying within 48 hours from the time they were loaded out and given a certificate of insepction. Often this decay, occurring in refrigerator cars in transit or while the potatoes were in cold storage, has been attributed to freezing injury. Recently some thought has been given to the possibility of this damage originating from heat injury during harvesting operations.

Investigational work on heat injury was started this year with the Irish Cobbler variety at the Irrigation Branch Experiment Station at Prosser, Washington. The object of the research was to determine the temperatures and exposures that are injurious to early potatoes and incidentally at what temperatures and exposures potatoes can be safely harvested.

The work was divided into three series. Series Number One consisted of digging a plot of potatoes each hour and gathering each plot after one hour's exposure. Example: tubers dug at 8 A.M. were picked up at 9 A.M., those dug at 9 A.M. were gathered at 10 A.M., and so on through the day. This gave exposure of potatoes to a variation of temperatures as the the temperature ranged from 77 to 103 degrees F. during the course of the experiment.

Series Number Two consisted of digging a plot of potatoes each hour through the day but allowing all plots to lie exposed until late afternoon. Example: tubers dug at 8 A.M. were gathered at 5 P.M.; those dug at 9 A.M. were gathered at 5 P.M. This provided for varying lengths of exposures of from one to nine hours.

Series Number Three was a duplicate of Number Two except that the tubers were given a one-layer and a three-layer burlap protection. This was designed to determine the protection possible when the potatoes are in sacks.

These three experiments were duplicated on two different days. Records were kept of the air temperature and the temperatures of the potatoes when dug at the end of their exposure period. The temperatures of the potatoes were taken with a thermometer so construcred as to allow the bulb to be pushed into the flesh of the potato. In each case the thermometer was pushed in deep enough to completely cover the mercury bulb.

The temperature of the potato lying exposed is considerably higher than the air temperature. When the air temperature the second day of the experiment was 103 degrees the temperature of the potatoes which had been exposed was 127 degrees F.

The highest temperature reached during the first day of the experiment was 91 degrees. At this temperature, none of the lots picked up after one hour's exposure showed any damage except the lot which was exposed between one and two in the afternoon. This showed some epidermal discoloration and some slight necrosis ten days after exposure. In the series exposed more than one hour, gradations of injury ranging from epidermal discoloration to mild black heart developed within 24 hours. The degree of injury increased with increased exposure. In 48 hours the injury had developed into severe black heart and necrosis discoloration and in ten days the lots showed from 10 per cent to complete breakdown with Leak, depending on the length of exposure. The only exception was the lot exposed from 3 P.M. to 5 P.M. which showed no injury at the 24 and 48-hour examinations but did show epidermal discoloration at the ten-day examination.

The highest temperature reached during the second day was 103 degrees F. The only lot not injured in the one-hour exposure series was the one dug at 8 A.M. and gathered at 9 A.M. The temperature at nine only reached 87 degrees. However, the next lot gathered at ten was exposed to 89 degrees for a short time and showed 20 per cent mild blackheart at the ten-day examination. All other hourly exposure lots showed serious epidermal discoloration in 48 hours and an average of 50 per cent breakdown with Leak in less than ten days.

Of the series exposed varying lengths of time for more than an hour, all showed severe blackheart injury within 24 hours and complete breakdown within ten days.

The potatoes exposed to heat with only one covering of burlap showed practically as much heat injury as those directly exposed to the sun. A three-layer burlap covering however, offered considerable protection although some discoloration and blackheart occurred in the tubers immediately adjacent the sunny side of the burlap.

From the foregoing results 90 degrees F. can be called the danger point in harvesting early potatoes. After the temperature approaches 90 degrees it is necessary to pick up immediately after the digging operation in order to avoid damage from heat injury. Sufficient pickers should be employed to prevent any tubers being exposed to the sun's rays for more than half an hour. When the air temperature approaches 95 degrees it is best to stop harvesting operations through the heat of the day and work only during the cool hours in the morning and evening. The pickers in Washington pick up in half sacks and by allowing the top of the sack to fold over and hang down on the side of the sack exposed to the sun, a three-layer burlap protection can be had. With this protection the sacks can be left in the field safely a couple of hours before any heat damage is done. Removing them as quickly as possible to the shed or some shade, however is advisable.

Pollination and Fertilization of Celery (Preliminary Report)

By S. L. EMSWELLER, *University of California, Davis, Calif.*

POLLINATION and morphological studies were undertaken primarily to aid in celery breeding work at the California station. The flowers are borne in compound umbels, the umbellets and flowers in the umbellets being arranged in whorls. Observations of many umbellets on various plants showed the outer whorl of flowers open first with successive whorls opening over a period of several days.

Self-pollination within the individual flower (autogamy) does not occur. Protandry is so complete that the first formed umbellets on isolated and caged plants do not produce seed. Flowers that open early in the morning usually lose most of their stamens by evening. Dehiscence of the anther usually takes place shortly after the flower opens; occasionally pollen is shed several hours before the petals have spread.

For a study of their development 400 flowers just fully opened were selected on different umbellets of various plants, and a thread was tied around each flower. At the time the flower is fully open, the styles are still compressed and folded against the stylopodium. After 36 hours the petals had begun to fall and the styles were just about in the same position as when the flower opened. After two and one-half days all the styles were beginning to rise, a few petals were found still clinging to the carpels, and all the stamens had been shed. After three days the styles were in a more vertical position, but they were not fully erect until the evening of the fifth day. Six days after opening they had begun to bend just below the stigmatic lobes so that they were in a spreading condition.

During the time the styles were moving from the horizontal to the vertical position, changes were going on in the cells composing them. The epidermal cells grew in size, and the granular inclusions increased greatly in number as the movement progressed. That portion which forms the stigmatic lobe was particularly well supplied with cells of this type, which gradually became papillae-like in structure. The organization of the cells forming this portion of the style is eventually very loose, and following pollination, disintegration sets in.

During this time the styles were growing rapidly and by evening of the sixth day all styles had fully spread. At this time the styles and stylopodium were covered with a transparent globular secretion. This was present from the fifth to the eighth day after the flowers had opened, at which time the styles of some were observed to be shriveling, indicating fertilization had taken place in some instances and not in others. From this it would appear that the period of receptivity lasts over several days; this supposition was verified when flowers were sectioned during this period of development.

To permit the study of conditions existing in the embryo sac during the periods mentioned, flowers were collected at intervals, killed, embedded, sectioned, and stained according to the usual methods.

At the time the flowers were fully open, the embryo sac was found to be nearly mature. At the micropylar end, the egg apparatus was found in all sections examined. The synergids were somewhat pyriform and placed a little above the egg. Fusion of the polar nucleii had already taken place, and the large primary endosperm nucleus was found near the center of the sac. Three antipodals were at the chalazal end, their arrangement varying: either one above with two placed side by side below it, or the three in a linear order, running parallel to the long axis of the sac. This condition continued for several days during which time the large fusion nucleus moved slowly up to a position directly beneath the egg. During this time there was a gradual disintegration of the antipodals, although their remnants could still be seen far down in the chalazal end of the sac. The cells immediately surrounding the embryo sac stain deeply which indicates that they are rich in nutritive material.

When the fusion nucleus moved up beneath the egg, the styles all began to move to a vertical position. This was on the evening of the third day. The location of the fusion nucleus, during the time the styles are changing their position, was unchanged.

Four and one-half days after anthesis, when the styles were first fully erect, the embryo sacs were mature. By noon of the fifth day, while the styles were all spreading, the condition of the sac was still unchanged. On the evening of the fifth day fertilization had taken place in some few instances. In two cases one embryo sac of a flower contained free endosperm nucleii, while the other did not. On the morning of the sixth day the majority of the flowers had free endosperm nucleii. However, it was not until approximately eight days after anthesis that fertilization had generally taken place.

Immediately following fertilization there was a rapid development of free endosperm nucleii. At first these nucleii were scattered, but soon became embedded in strands of cytoplasm that lined the periphery of the sac. In a very short time the sac was crowded with nucleii, making it somewhat difficult to find the fertilized egg, which remained in a dormant condition for a period of two to four days after the endosperm had begun dividing. When the first walls were found in the endosperm, the embryo had not yet begun to divide, but had enlarged somewhat. Approximately 24 hours after wall formation in the endosperm, two-celled embryos were rather plentiful; and three days later a few four-, six- and eight-celled embryos were found. From this point on development was rather rapid.

A count was made of the chromosome number. Over 100 counts were made in the cells of the growing root tip; the diploid number was found to be twenty-two (22). The haploid number eleven (11) was observed in the heterotypic division of the pollen mother cells.

Cultural Practices and Green Asparagus[1]

By Victor A. Tiedjens, *Experiment Station, Waltham, Mass.*

THERE has been a gradual trend toward the production of green spears in the culture of asparagus. The better flavor and greater demand for green asparagus has placed a premium on its production.[2] But even though the green spears bring more money, there is considerable doubt in the minds of growers whether the additional growth necessary for the production of green asparagus is reducing the yields through root exhaustion and thereby reducing the net returns for the crop.

An experiment was started in May 1927, at the Field Station of the Massachusetts Agricultural College at Waltham, to determine the effect on yield of various lengths of green on the spears. Two small areas in commercial fields were used for the purpose through cooperation with two growers. One field was five years old and the other was twelve years old. Spears showing four, and spears showing eight inches of green were cut from four hundred plants in each plot. The spears were harvested daily, trimmed to eight inches, counted, and weighed. The results may be summarized as follows:

In the five year old bed, very thrifty and well cared for, there was no difference in number of spears to a plant and only a slight difference in weight between the four- and eight-inch green plants. The eight-inch green required one more spear to make a bunch of asparagus, due to the decrease in size as the spears grew higher. The average diameter of the spears in either lot did not change throughout the cutting period.

On the twelve-year-old bed, producing small spears and showing signs of root exhaustion, there was no difference between the four- and eight-inch green in number of spears to the plant, but there was a 23 per cent decrease in weight of spears for the eight-inch green plants due to the fact that there was a gradual decrease in size of spear as the cutting season advanced. This difference was significant because many spears that should grade fancy when showing four inches of green were seconds when showing eight inches of green.

In addition to these plots, three series of seventy-eight plants each were staked in a field so that the spears on plant No. 1 were cut when four inches of green showed; plant No. 2 when six inches of green showed; and plant No. 3 when eight inches of green showed. Plant No. 4 was a repetition of No. 1; Plant No. 5, of No. 2; and similarly throughout. This was done to overcome any segregation of weak or

---

[1]Contribution No. 90, Mass. Agr. Exp. Station.

[2]A study of the factors influencing the price of asparagus on the Boston Market for 1927, conducted by Frederick V. Waugh and Julius Kroeck of the Massachusetts Division of Markets, showed that every additional inch of green brought 38.5 cents for each dozen bunches and accounted for 41 percent of the fluctuation in price. Number of stalks per bunch accounted for 15 percent of the fluctuation in price, and each additional stalk necessary for a bunch decreased the price 2.2 cents per dozen bunches. The importance of quality is emphasized. A similar study in 1928 corroborated the results of 1927.

strong plants in a given row. The plants had been set three by four feet so that records for individual plants could be made. During warm weather it was necessary to cut the spears twice a day. The plants were three years old and were cut for five weeks. Daily records were kept on number of spears produced by each plant and the average diameter of the spears. Data were also collected at certain times to show the decrease in average size of the spear when permitted to grow from four to eight inches of green.

The results[3] are more conspicuous for their indications of the influence of contributing factors than for the solution of the problem on relation of amount of green to yields of individual plants. Harvesting of spears was discontinued before any indication of food exhaustion occurred so that the spears did not decrease in size as the season advanced. A comparison of size of spears for the various plants shows a remarkable uniformity and indicates the importance of heredity in determining the maximum size of spear for each plant. There is a negative correlation between size of spears and number produced by each plant.

The difference in weight between the four, six, and eight-inch green plants was not significant although there was an indication that the eight-inch green spear was not drawing as heavily on the root reserves as the six-inch green spear. It is a question whether synthetic activity had any bearing on this indication. There was an average decrease of 30 per cent in size of spear from the four- to the eight-inch green which is significant under our methods of grading where diameter of spear is one of the factors in determining the various grades.

Discussion of Experiments

The problem concerning the effect of amount of green on yield depends on the amount of reserve food in the roots and the quantity needed to produce a given spear. It is reasonable to suppose that an eight-inch green spear will take more energy from the root than a four-inch green spear because of the additional growth of tissue necessary. As the spears grow in height they gradually decrease in size, so that the closer the marketable spear is to the crown the better chance there is of classifying it with the fancy grades.

It is reasonable to suppose that when a plant reaches genetic maturity it will store sufficient reserve food in its roots to develop a stalk from each of its buds if necessity demands. However, it is only under cultural conditions that the plant is called upon to develop all of its buds into stalks. When spears are cut, many dormant buds are activated because the survival of the plant is jeopardized. This produces spears of various sizes on plants, the buds on which

[3]It is realized that these results are fragmentary and premature when applied to the solution of the problem. They are reported because of indications toward expected results and the relation of the problem to other cultural practices. The first year's results showed that depth of planting must be considered in this study. A planting was made in April 1928 on which a much better controlled experiment can be conducted, and which will consider some of the factors contributing to the real problem.

are not genetically mature when the first spears are cut. The small spears are not an indication of exhaustion of the food reserves when accompanied by large spears. On old beds, small spears are produced on plants weakened by cultural practices and can be attributed to insufficient root reserves. There is a relationship between root reserves and spear production which has direct bearing on the production of green asparagus.

It is necessary to adapt cultural practices to meet the new market demands because the practices used for white asparagus are costly and may have injurious effects on plantations where green asparagus is harvested. This brings the discussion to a consideration of the first problem, which is depth of planting.

Depth of Planting

If the whole spear must be green, it is not necessary to cut the spear below the surface of the ground. Therefore, it is not necessary to plant the roots as deep as has been the practice. Immediately the questions are asked, "Will the spears be as large?" and "Will the beds last as long?" There is no experimental evidence that spears will not be so large or that the beds will not last so long, but there is considerable evidence that the advantages in favor of shallow planting over-balance the disadvantages. If we assume that the size of buds and spears is determined by hereditary influences, the first question will have no bearing on the problem. As for prolonging the life of the bed, shallow planting has the advantage because of the more vigorous development of the plants. Shallow crowns will produce more top growth in a season and naturally reach genetic maturity earlier. This makes it possible to start harvesting earlier with much less injury to the crowns. Very few skips occur among shallow-planted crowns. This is a decided advantage.

It seems reasonable to suppose that if a spear is cut close to the crown it will be larger and tax the reserve foods less than if the spear must grow through eight inches of soil in order to produce its marketable portion above the ground. When comparison is made between the fact that a crown will grow toward the surface in eight to ten years, and reports that beds are known that yield well after fifty years, statements that shallow planting will shorten the life of a bed may be discounted.

The advantage for deep planting is the ease with which the disc harrow can be promiscuously used on the beds to work tops, manure, and weeds into the soil. However, the practice of planting deep so that the disc harrow may be run over the beds defeats its own purpose because in six to eight years the crowns are so close to the surface that the use of the disc harrow may result in severe injury to the beds.

There are more cases of short-lived beds because of careless cultivation than from any other source. When it is realized that English gardeners plant asparagus crowns three inches deep and get good yields for many years, depth of planting does not seem the sole factor responsible for low yields and short-lived beds.

Length of Cutting Season and Culture

The length of the cutting season is determined, in too many cases, by the time of the year rather than by the condition of the beds. Many low-yielding, weak beds are the result of excessive cutting, not in late harvesting but in the cultural practices that follow the end of the cutting season. When beds are producing an unusually large number of small spears toward the end of the cutting season, it is an indication that the stored reserves are at a low level; and if the cutting does not cease, the beds will grow weaker from year to year.

Many growers in New England will cut until the tenth to the fifteenth of July and follow the last cutting with cultivation by a tractor disc harrow. With level culture there is considerable damage done, and many aggravate the situation by hilling up the rows during the cutting season to kill weeds. Ask these growers whether they would cut their beds until the first of August and they would say, "Absolutely no!" Yet leveling the ridges after the cutting season, is far worse because of all the buds that are broken off. A large number of small spears make their appearance after a long interval because the food reserves have been severely taxed. Root exhaustion means low yields of low grade spears.

Cutters and Yields

The question is often asked whether the method of cutting has anything to do with yield of spears. The practice of hiring inexpensive labor may have considerable bearing on the yield of high grade spears. Mr. Burnley, one of the large growers near Seekonk, Massachusetts, had the idea that some of his cutters were losing money for him. He had a family consisting of a mother, three daughters, and a son cutting for him, and he planned a little experiment in which he set aside a definite number of rows for each one to cut during the season. The results were most interesting and instructive.

Harvested by mother	185 pounds—quality excellent
Harvested by eldest daughter	205 pounds—quality excellent
Harvested by youngest daughter	165 pounds—quality good
Harvested by middle daughter	90 pounds—quality poor
Harvested by boy of high school age	74 pounds—quality poor

In analyzing the results Mr. Burnley said the mother and eldest daughter made one deliberate thrust with the knife to cut each spear. The youngest daughter was a little careless, while the other daughter and the boy paid little attention to buds in close proximity to the spear they were cutting, and damaged many. Where the season's crop of buds is determined the previous season, it is easy to see how the mutilation of these buds may result in poor yields and poor quality, especially where practically all white spears are cut.

Conclusion

Apparently the practice of cutting green asparagus has less effect on yield than certain cultural practices. The relation of green asparagus to yield is one in which depth of planting is important because one of the big factors, damage from careless cutting of spears, is eliminated. It is necessary to adopt methods of cultivation so that shallow crowns will not be injured. On deeply planted roots, yields will be influenced more by cultivation and harvesting than by the amount of green on the spear. The growers' chief concern should be to develop each bud into a fancy spear and satisfy market demands. The effect on yield of cutting four-, six- or eight-inch green is of little importance when compared to the large influences that cultural practices have on yield. From the market standpoint the grower apparently has no choice. He must hold his market and his prime consideration must be to produce green asparagus of first quality as economically as possible.

A Summary of the Performance Records of Individual Asparagus Plants in 1928

By L. G. Schermerhorn, *Experiment Station, New Brunswick, N. J.*

IN order to determine the type of asparagus best suited to commercial production, about 1500 plants at New Brunswick during the fall of 1927 were classified as to sex, diameter, and number of stalks per plant. This classification showed that the plants which exhibited a large stalk diameter in the fall, 18 to 22 mm. were represented by two principal types of fall top growth, one with many stalks, 10 or more, and by another type with few stalks, 6 or less. The storage roots of both the many and few stalked types had more large buds than either small or dormant buds and the storage roots were from 6 to 8 mm. in diameter. Also there were individual plants exhibiting a small diameter of stalk in the fall, 6 to 10 mm. that, like the large diameter groups, had some plants with many and some plants with few stalks. The predominating type of the small diameter group had many stalks and the storage roots were from 4 to 6 mm. in diameter with few large buds but comparatively many small and dormant buds.

Roots from plants with an extremely large stalk diameter in the fall, 18 to 22 mm. had as an approximate mode 25 large, 11 small and 8 dormant buds. Plants with a fall stalk diameter of 6 to 10 mm. had an approximate mode of 2 large, 56 small, and 46 dormant buds.

It has been found that the diameter of brush does not necessarily indicate the diameter of the spears that may be cut the following spring. A more accurate index of plant performance is the actual diameter and number of spears per plant, though it appears that as a rule, for each stalk on the plant the previous fall, there are produced 2.75 spears the following spring under our environmental conditions and with a cutting season of 10 weeks.

The records show that some plants may produce no spears or only one or two, while others may produce over 100 spears. Some individuals cut nearly every day whereas others cut only once in two or three weeks. In addition some plants begin to cut early in the season, some in midseason and others very late in the season. In all of these seasonal groups both staminate and pistillate plants occur. It would appear from the records that in the Martha Washington and Palmetto varieties as they exist today there are both early and late strains as well as high and low yielding strains of both staminate and pistillate plants.

It is hoped that the use of these individual performance records of earliness, lateness, quantity, and quality of spears will make it possible to select parent plants from which may develop a strain of asparagus that will produce, more uniformly as to time of cutting, a larger proportion of prime and colossal size spears and a greater production from each plant than is being secured at the present time. Such a strain should make it possible to plant smaller acreages without loss of monetary return.

Does Root Selection Accomplish Its Purpose In Asparagus Culture?[1]

By Victor A. Tiedjens, *Experiment Station, Waltham, Massachusetts.*

ROOT Selection in asparagus culture has been advocated for a number of years with varying success, and still the question is asked, "Does it really accomplish the expected result?" The question may be answered "Yes" or "No," with certain modifying qualifications. Myers (1) found that there was very little difference in yield between large and medium roots, but that there was a decided yearly difference in yield between the small and medium roots. Growers who have observed plants in the field say that weak or small plants will become high-yielding plants if given a chance.

Theoretically asparagus plants from a field run lot of seed should be expected to vary from potentially very weak- to very strong-yielding types with the largest percentage of roots classifying midway between the two extremes. Data for yield on individual plants will substantiate this supposition. That being the case it should be possible, theoretically, to select roots of various types from a lot of one-year-old plants, basing the criterion for selection on size of root. This is possible if the roots are properly grown but it does not give practical results that will agree with the theoretical expectation because of the influence of environment on the development of the roots. The commercial method of growing roots is to plant the seed thickly, paying no attention to spacing. Sometimes the seedlings are thinned, but usually the thinning is done so late in the season that only the tops are pulled off, so that the root is weakened but not killed, and will grow sufficiently to interfere with the larger roots late in the season. These small roots may have genetic potentialities for large yields. There is no method whereby potentially large roots may be identified early in the season, and for this reason the percentage of large roots may be materially reduced by thinning. Roots grown in a nursery in this manner are unsatisfactory for formulating any reliable method of root selection.

Experiments were started by the Massachusetts Agricultural Experiment Station in April 1924, for the purpose of throwing further light on the problem. Field run roots for the experimental plot were divided into four groups according to size. Each group was subdivided into four classes on the basis of the number of bud clusters per crown: Class I having one cluster, Class II having two clusters, Class III having three clusters, and Class IV having four clusters or the buds generally distributed over the crown. The fact that each group could be divided into four classes indicated that there was no correlation between size of root and number of bud clusters. Four-bud-cluster crowns were as frequent among the small as among the large roots. Each class was planted separately and data taken on the first and second summer's growth. The results do not

[1]Contribution No. 89, Mass. Agr. Exp. Station.

show what type of roots should be selected for a high-yielding bed, but they do emphasize the importance of some of the controlling factors that must be considered in dealing with the problem. The present paper, therefore, is not a discussion of an experiment showing how to select roots, but a discussion of some of the reasons why such results as Myers secured do not show closer harmony with theoretical expectations.

Discussion of Observations and Data

The results were full of indications but lacking in convincing data that root selection was a guarantee that the permanent bed would be high producing. There were many of the small and medium roots that yielded as well as the large roots showing that a high percentage of potentially high yielding roots are discarded where selection is made from field run roots. The small roots showed a 13 percent mortality as compared with 4 percent for the large roots. This, of course, is a big advantage in favor of root selection. Even though the practice of root selection is considered profitable in most cases, it is difficult to secure data that will convince the grower that selected roots are necessary for a profitably yielding bed. Nor is it sound advice to ask the grower to consider only the upper 10 percent as large roots. Selecting the large roots, a small percentage at best, from field run seed gives a good yielding bed, but a large percentage of the medium and small roots also produce high yielding plants. However, since there is no method of determining which of the small and medium sized roots will develop into high yielding plants, the grower has a choice of selecting for his planting the small percentage of large roots, or planting all but the smallest roots. Selection within the medium sized roots is a waste of time.

In order to determine the cause of this latent development, a critical examination of the growing of roots was undertaken. Although the results are more or less preliminary, certain deductions can be made and observations can be noted which have important bearing on the problem.

If records are kept for 1,000 plants, giving the number of spears and stalks for each plant for several years, it will be found that the data when classified shows the average plants between the lowest and highest yielding plants include over half of them. Those producing the largest yields will be very much in the minority. The plants will yield from one to fifty spears during a normal cutting period.

Norton (2) shows that there is a direct correlation between size of seed and size of root. Theoretically it should be possible to select the large seed and increase the percentage of large roots. Weights of seeds from individual plants show that when seeds of similar weight are grouped they will also form a distribution curve. However, weight and size of seed are not necessarily synonymous, so that separation of the seed by mechanical means or specific gravity will not separate all large plant producing seed and the theoretical expectation will be considerably larger than the actual count. In compar-

ing distribution curves for weight of seed from different plants, the mean is seen to vary considerably. As an example, the mean weight of 100 seeds from one plant will be 2 grams as compared to 3.8 grams for another plant. The size of seed will likewise vary. The roots from these respective lots of seed show considerable resemblance for size, each lot producing roots varying from small to large. The number of seeds in a berry, which varies from one to eight, determines the shape of the seeds because one seed in a berry will be a sphere, while seeds from a four-seed berry will be the shape of a quarter sphere. Mechanical separation will not, therefore, give the desired results. Nor will specific gravity separate the high from the low producing seed, because the relation of volume to weight of a seed from a one-seed berry will be different than for a seed from an eight-seed berry. Either one may have potentialities for a high-yielding root. Indications lead us to assume that genetics has considerable bearing on the distribution of yielding capacity in asparagus roots, and technique involving these studies must consider the problem beginning with the source of seed.

The only true selection basis would be to concentrate on the seed from one plant, plant the seed by the centgener method (used in cereal breeding investigations), and select the roots from each lot. This is feasible for the investigator but impractical for the grower so that other methods must be used which will reduce environmental factors to a minimum. For practical purposes mechanical separation of the seed will increase the percentage of large-yielding roots to a certain extent, but unless the roots are properly grown selection of high-yielding crowns will still be uncertain. Environmental factors must be controlled so far as human ingenuity can prevail.

Consideration of Environmental Factors

There are a number of factors affecting the efficacy of root selection which, to a certain extent, can be controlled to make root selection serve its purpose. Seed planted by ordinary methods gives roots of various sizes, but the sizes are due to environment as well as hereditary potentialities because of the uneven distribution of seed. Assuming that seed varies in its genetic potentialities for vigor, a seedling having high-yielding potentialities with room to grow will show its hereditary possibilities, but if it is grown close to another seedling it may not be as large as a seedling with low-yielding potentialities growing free from the influence of another. In addition to decreasing the size of the root by crowding, there is a lack of development of buds on the crown which is of greater importance. Crowns vary in the distribution of buds. If roots are growing in close proximity, the clusters of buds will not develop freely so that a potential two or three bud cluster crown will show only one cluster of buds and will be discarded. Even though this may not affect the commercial planting except to reduce the number of large roots, it would upset results in an experimental plot because potentially large roots that are small because of environment will develop rapidly when given a chance. This occurred in the experimental planting previously

mentioned, and although the percentage of high-yielding plants among the one-cluster crowns was considerably smaller than in the two- to four-cluster crowns, it was high enough to make differences between the lots negligible.

It often happens that even selected roots of good size will be weak and die the first year. There is a very feasible explanation for this, but it is not the only explanation because so little is known of the genetics of the variety. If, in the nursery, the tops of a large root are broken off late in the season so that a number of spears are sent up and do not have a chance to branch out before freezing weather, the stored food is sufficiently exhausted to weaken the root and it may be injured by freezing. It may die the first year or produce a weak growth, and will not become established before the field is cut. It may remain a weak plant for a number of years or may die after the first cutting season.

Application to Commercial Plantations

The grower's problem is to grow his roots in as uniform an environment as possible, and make a narrow selection for size and crown characteristics. The first objection is that such a method would make the roots costly, but when the cost of roots is compared with other costs in the establishment of the bed and the time that the bed occupies the field, such precautions seem very much worth while. Why should not asparagus culture be put on a basis with apple or small fruit culture? If it pays the fruit grower to pay more for a good apple tree, would it not pay the asparagus grower to spend more time and money on the production of his asparagus roots? The proper spacing of graded seed in the nursery combined with proper root selection is worthy of much more consideration and will materially increase asparagus yields. Even though it has not been possible to demonstrate clearly the advisability of root selection, it is assured that it can be demonstrated if certain controlling factors are eliminated. The premises for root selection apparently are sound but the technique has been faulty.

Literature Cited

1. Myers, C. E. In Ann. Rept. Penn. State College, 563–576. 1915–1916.
2. Norton, J. B. Methods used in breeding asparagus for rust resistance. B. P. I. Bul. 263. 1913.

The Transpiration Rate of the Pinto Bean*

By T. M. Currence, *University of Minnesota, University Farm, St. Paul, Minnesota.*

THE study here reported was an attempt to compare the water relations of the Pinto bean with those of a standard garden variety. The data were obtained while the writer was at the Oklahoma Experiment Station. According to Freeman (1) beans of this type have been grown for several centuries by the Indians of the southwest. This variety is still grown there and is considered as one of the best adapted to the prevailing drought conditions of that region. If this bean can then be considered as drought resistant, a study of its water absorbing and water losing powers might be expected to indicate something of the nature of drought resistance.

The transpiration rate of Pinto was compared with that of the well-known variety Stringless Green Pod. This was done by growing, under greenhouse conditions, twelve hermetically sealed pots of the former and ten of the latter, and determining the water loss from each pot over a period of one week. A glass tube inserted into the soil was used to add water to the plants daily. In this way the soil moisture was kept constant, aside from daily changes. At the end of the period the plants were cut off at the surface of the soil and the water lost from the pots during the next 24 hours was determined for use in correcting the total water loss. The loss from the pots after removing the tops of the plants was negligible. The soil was washed from the pots, care being taken to injure the roots as little as possible. To eliminate adhering moisture, the roots were air dried for 24 hours.

By measuring the leaf areas and weighing the root systems of individual plants of each variety, it was possible to make certain comparisons between the varieties. The comparisons made were the rate of water loss per unit of leaf area, the water loss per unit of root weight, the amount of leaf area per unit of root weight, and finally the relation of water loss per leaf area to the amount of leaf area per unit of root weight.

The grams of water lost per square meter leaf area per hour (gm^2h) for the Pinto gave a mean of 48.13 ± 0.83 while that for the Stringless Green Pod was 42.29 ± 1.29. The probable errors were calculated by Bessel's formula. The difference between the means is 5.84 ± 1.53. The figures for individual pots are given in Table I.

*Published with the approval of the Director, as Paper 825 of the Journal Series of the Minnesota Agricultural Experiment Station.

TABLE I—RATES OF WATER LOSS IN RELATION TO LEAF AREA FOR THE TWO VARIETIES

Plant Designation Numbers	Total Water Loss (Gms.)		Leaf Area (Sq. Meters)		Gms. Water Loss per Hour per Sq. Meter Leaf Area	
	Pinto	Stringless Green Pod	Pinto	Stringless Green Pod	Pinto	Stringless Green Pod
1	170	64	.0208	.0101	48.71	37.62
2	325	87	.0363	.0118	53.26	43.87
3	315	265	.0399	.0341	46.99	46.31
4	222	258	.0349	.0355	37.86	43.20
5	173	183	.0220	.0263	46.81	41.39
6	326	147	.0414	.0196	46.93	44.62
7	153	403	.0197	.0581	46.13	41.27
8	113	—	.0128	—	52.39	—
9	116	265	.0128	.0462	54.06	34.15
10	96	128	.0121	.0215	47.11	35.36
11	270	129	.0324	.0139	49.60	55.11
12	201	—	.0251	—	47.68	—

The mean of the hourly water loss to one gram of roots for the Pinto was 1.967 ± 0.068, and for the Stringless Green Pod was 2.563 ± 0.094. The difference of 0.596 ± 0.116, is more than five times its probable error. The individual ratios are shown in the last two columns of Table II.

TABLE II—RELATION OF ROOT SYSTEM TO LEAF AREA AND WATER LOSS FOR THE TWO VARIETIES

Plant Designation Number	Weight of Roots (Gms.)		Gms. Roots to One Sq. M. Leaf Area		Water Loss per Hour per Gm. of Root Wt.	
	Pinto	Stringless Green Pod	Pinto	Stringless Green Pod	Pinto	Stringless Green Pod
1	0.7894	0.1951	37.95	19.32	1.282	1.953
2	0.3777	0.2186	10.40	18.53	5.122	2.369
3	1.2842	0.6211	32.18	18.21	1.460	2.540
4	0.9554	0.4308	27.38	12.14	1.383	3.565
5	0.5328	0.3839	24.21	14.60	1.933	2.837
6	0.6896	0.3596	16.66	18.35	2.814	2.433
7	0.8748	0.9504	44.41	16.36	1.041	2.524
8	0.4960	—	38.75	—	1.356	—
9	0.3147	0.6875	24.59	14.88	2.194	2.294
10	0.3745	0.2676	30.95	12.45	1.526	2.847
11	0.8599	0.3392	26.54	24.40	1.869	2.204
12	0.7348	—	29.27	—	1.628	—

Since the two types of beans appear to differ in their transpiration rates in relation to leaf area and root system, a comparison of the ratios of root weight to leaf area is of interest. The Pinto was found to have a significantly greater root system in proportion to its leaf area than had the Stringless Green Pod. The means for the grams of roots to one square meter leaf area are: Pinto 28.67 ± 1.833 and Stringless Green Pod 16.92 ± 0.781. The difference here is 11.75 ± 1.99 and is approximately six times the probable error. Having a greater root system in proportion to leaf area, suggests an explanation

for the drought resistance of the Pinto. Obviously, under arid conditions, this characteristic would be expected to enable the plant to take up a greater amount of soil moisture to accommodate the rapid evaporation from the leaf surface. A large absorbing area and a small evaporating surface probably are important factors in maintaining the turgidity of a plant, growing in an environment favorable to rapid evaporation; or with a limited supply of soil moisture available.

An attempt to illustrate the effect of root system per leaf area on water loss per leaf area is made in presenting Figs. 1 and 2. In future work it is hoped to secure further data on this phase of the problem by varying the conditions for transpiration. However, the limited data now available may be of interest. Fig. 1 representing Pinto suggests that under the conditions of this experiment there was

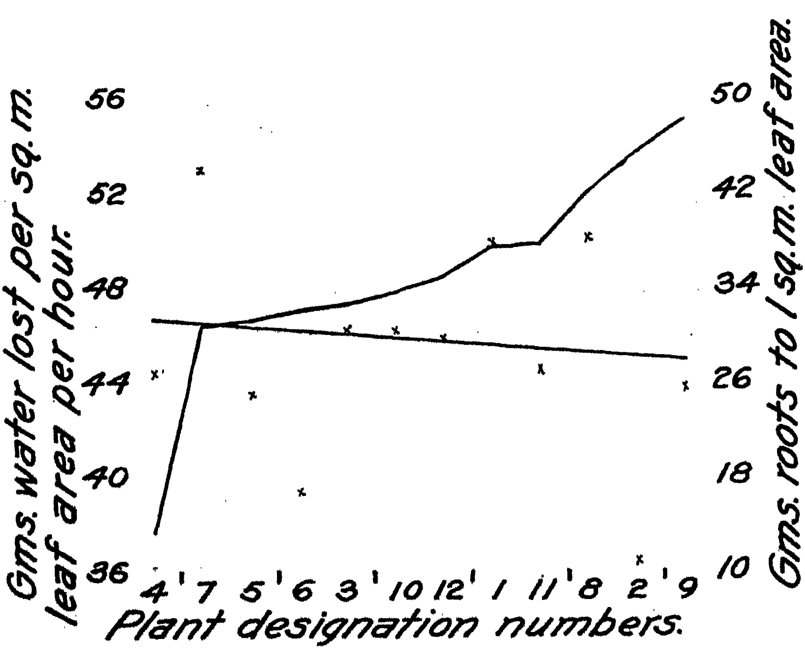


FIG. 1. Series arranged in ascending order for water loss per square meter leaf area per hour and the root weight per square meter leaf area for corresponding plants fitted to a straight line. Pinto variety.

little or no relation between the two ratios. The basis for this statement is shown by the wide divergence between the locations of the points for which the straight line is drawn. This condition probably would not exist under more arid conditions. It seems a logical assumption, in the case of this variety, that the atmospheric conditions under which the plants were grown were not sufficiently arid to make full use of the water absorbing powers of the plant root system.

That the rate of water loss was being affected by the extent of the root system in case of Stringless Green Pod, is indicated by Figure 2. Not only does the straight line tend to follow the curve, but its points

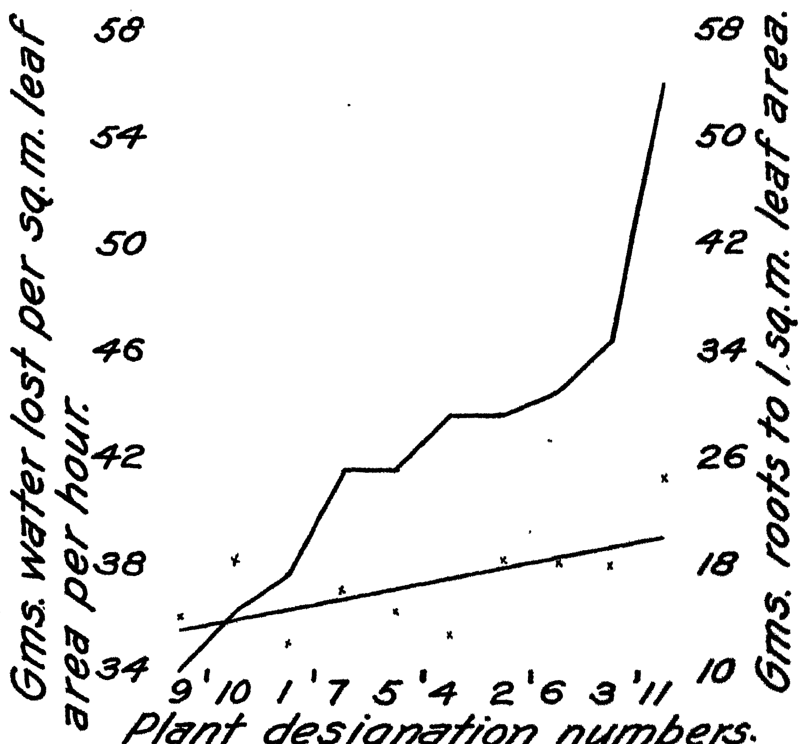


FIG. 2. Series arranged in ascending order for water loss per square meter leaf area per hour and the root weight per square meter leaf area for corresponding plants fitted to a straight line. Stringless Green Pod variety.

are also located within a comparatively narrow range. It would, therefore, appear that even under greenhouse conditions, this variety may approach its limit of water absorbing capacity.

LITERATURE CITED

1. FREEMAN, G. F. Sothwestern beans and teparies. Ariz. Agr. Exp. Sta. Bul. 68. 1912.

Studies on the Reaction of Greenhouse Soils

By W. W. Wiggin, *Experiment Station, Wooster, Ohio.*

HYDROGEN-ION concentration has been studied in practically every branch of Science within recent years, and a great deal of scientific importance has been attached to it. The following paper deals with the hydrogen-ion concentration of greenhouse soils.

Dr. Edgar T. Wherry was one of the first workers to deal with the subject of soil reaction. As a result of his work many of our plants have been listed as to their preference for acid, alkaline, or neutral soil. Dr. Wherry drew his conclusions from tests for the reaction of soils in which the plants were found growing luxuriantly.

P. Arrhenius, C. H. Farr, and many others have worked with forage plants and the root hairs of vegetables, but we know of no work having been done with the commercial flower crops under greenhouse conditions. Most of the soil reaction work has been done under growing conditions in the field, where the reaction has been found to vary with the seasons, time of season, depth of readings, and other factors.

In July, 1927, a silt loam soil of medium organic content having a pH value of 5.0 was placed in a raised greenhouse bench, 50 feet long, 7 feet wide, and 5 inches deep. After titrations had been made to determine the approximate amount of air slacked lime necessary to change the reaction a given amount, the bench was divided into eight plots. Lime was applied to give the plots a pH value of 5.0, 5.5, 6.0, 6.5, 7.0, 7.5, 8.0, and 8.5, respectively.

The plots thus laid off have been tested with a LaMotte soil tester at approximately two-week intervals. The samples of soil were taken with a cork borer, taking four borings per plot thru the entire depth of the soil in the bench. The electrometric method was used to check the LaMotte method, and the latter was found to be accurate to 0.2 to 0.4 of a pH, or having no more error than there would be in sampling the soil. The plots were watered with rain water whenever this was available, and lime or aluminum sulphate added to keep the reaction as near the desired figure as possible in a plot of soil of this size.

Plants were set in rows lengthwise of the bench, the same number in each plot, to determine where the maximum and minimum growth occurred within these ranges of soil reaction. The plots were treated as nearly alike as possible as to nutrition and other cultural practices outside of the additions of lime and aluminum sulphate.

For the work with pot plants, lime and aluminum sulphate were added to more of the same soil to obtain a pH of 4.0, 5.0, 6.0, 7.0, and 8.0 and the plants potted into these media after they had reached sufficient growth in ordinary compost with a pH of 7.4. These plants likewise received the same care with the exception of the soil modification treatments. It was found necessary to grow the plants

to a fair size before subjecting them to the different treatments as some made little if any growth after being potted into the soil with very low or high reaction.

The pot plants under each pH value were divided into four lots of 10 plants each. One received no additional fertility, while the other three received different fertilizers applied in liquid form. These plants were used to determine whether the fertilizers acted differently when applied to soils of different reactions.

Carnations, sweet peas, chrysanthemums, pompons, calendulas, snapdragons, and stocks were grown in fertilizer plots in the Station greenhouses, Fifteen treatments being applied to each crop, and duplicate plots were carried in cooperative experiments in commercial greenhouses. The pH values of these plots were determined at the time the crop was set, at two- to four-week intervals while the crops were in the soil, and at the time of crop removal. As the plots receive the same fertilizer each year, a fairly good idea of the reaction that each treatment produces on the soil is obtained.

Flowers of a similar stage of maturity were picked from each plot at intervals and placed under living room conditions to determine to what extent, if any, their keeping qualities were affected by the different soil reactions. Color of the flowers and foliage during growth, extent of root growth at time of removal of the crop, and other important growth characteristics were carefully watched for any symptoms that might detract from commercial value. Individual plant records were kept on all plants used.

The work is not complete, but a summary of the findings to date are as follows:

Snapdragons (two crops) gave the greatest number of flowers with a pH of 6.0 to 6.5 and the best stems with a pH of 7.0 to 7.5.

Calendulas (two crops) gave the greatest number of flowers and the best stem development on the pH 8.0 plot. Root development was much poorer in the very acid plots.

Carnations (one crop) gave the greatest number of flowers with a pH of 6.5. The stems showed little preference for any one treatment.

Chrysanthemums (two crops) gave the largest flowers and best stems on the pH 6.5 plot. The chrysanthemums on the pH 8.5 plot showed a slight yellowing of the foliage and the blossoms turned brown on the outside tips of the petals soon after opening, so that they were unsalable.

Cyclamen showed a preference for a soil with a pH 5.0 to 6.0.

Primula malacoides was very sensitive to acid conditions. Those growing in a soil of a pH 5.0 and to which liquid manure was added died within two weeks after the treatment was given, and those placed in soils of pH 4 and 5 grew little if any after being potted.

Primula obconica preferred alkaline conditions.

Hydrangeas preferred acid conditions, and were very sensitive to the treatments given. Those in soil with a pH of 4.0 made good

growth but the flowers turned blue. Those in a pH 5.0 gave an occasional blue flower, while those in the 6.0 came true to color. The more acid the treatment the better the growth and color of the foliage and these diminished as the soil became more alkaline. The very alkaline treatments gave stunted growth and a decided yellowing and mottling of the foliage, which could not be overcome by watering, feeding, or any other method tried.

Geraniums, callas, and cineraries showed a preference for alkaline conditions.

Coleus was the only crop grown that seemed to do equally well in all ranges of soil reaction.

It was very difficult to keep the plots at the desired reaction, and in the case of the pot plants it was almost impossible after the first few weeks, supposedly because of the leaching of the chemicals with the constant watering which pot plants require. Those plants which are ordinarily grown in pots are this year being grown in the bench plots as well to check on this difficulty.

The water tested in greenhouses in Ohio all showed alkaline reactions, which tends to make the soils more alkaline.

Some crops tend to change the hydrogen-ion concentration of the soil in which they are grown. Where snapdragons and chrysanthemums were grown the plots had a tendency to become more acid, while with the carnations and calendulas there was a tendency for the soil to become more alkaline.

There was no appreciable difference in the color of the flowers or keeping qualities, with the one exception of the chrysanthemums as already mentioned.

With the exception of the hydrangeas and cyclamen, all of the crops tried could be grown with commercial success on the range of pH values one finds in the majority of greenhouse soils. Extreme reactions are marked by a stunting of growth, yellowing of foliage and a general unhealthy condition of the plant.

The final reactions of the soil resulting from the continued use of the various fertilizer treatments are as follows:

Cow manure—alkaline; bone meal—slightly alkaline; nitrate of soda—very slightly alkaline; 3–12–4 (nitrate of soda, superphosphate and muriate)—alkaline; superphosphate—uncertain; lime—alkaline; vigoro—alkaline; slag—alkaline; peat moss—neutral to slightly acid; and sheep manure—alkaline.

Contrary to reports, altho peat moss tested pH 3.8 when applied to soil at the rate of ten tons per acre it gave little if any change in the soil reaction.

Sheep manure showed the quickest reaction of all the materials used. With the exception of slag, lime, and sheep manure the materials used did not change the soil to any great extent; not enough, at least, that they could be recommended for soil reaction modifiers. After many years of cropping in beds, this probably would not hold true.

The same type of work has been running for one season on annual and perennial flowers under field conditions. Great difficulty has been encountered in obtaining a constant reading in the plots. Hydrangeas in the field showed the same results as the pot-grown plants altho the plots did not run decidedly uniform thruout all of the growing season.

Literature Cited

1. Farr, C. H. Studies on the growth of root hairs in solutions. III. The effect of concentrations of $CaCl_2$ and $Ca(OH)_2$. Amer. Jour. Bot., Vol. XIV, No. 10, 553–564. 1927.
2. ————. Studies on the growth of root hairs in solutions. V. Root-hair elongation as an index of root development. Amer. Jour. Bot., Vol. XV, No. 2, 103–113. 1928.
3. Wherry, E. T. Soil reaction in relation to Horticulture. Amer. Hort. Society, Bul. 4, 1–14. 1926.
4. ————. Divergent soil reaction preferences of related plants. Ecology, Vol. VIII, No. 2, 197–206. 1927.

The Inter-relations Between Growth of Spinach and Culture Medium Reactions.*

By H. H. Zimmerley, *Va. Truck Experiment Station, Norfolk, Va.*

SPINACH has been classed by Burgess and Pember (1) in the group of plants shown to possess a low resistance to soil acidity and aluminum toxicity. In experiments at the Virginia Truck Experiment Station (2) a soil reaction value between pH 6 and pH 7 usually proved optimum for the growth of spinach on several types of soil. Under favorable moisture and temperature conditions, accompanied by an abundance of available plant food, no marked retardation of growth was noted on soils less acid than pH 5.5. Below that point the injurious effects of acid soils was very pronounced and below pH 4.5 most of the plants died in the seedling stage. The Rhode Island (1) workers attribute the injurious effects of acid soils to aluminum toxicity rather than to the H-ion concentration *per se*. In experiments at the Virginia Truck Experiment Station the writer found that acid phosphate only partially corrected the injurious effects of acid soils on the growth of spinach, and concluded that factors other than aluminum toxicity may have been partly responsible for retardation of growth.

The results of a number of workers (3, 4, 5) with solution cultures indicate that a definite inter-relation exists between the H-ion and O H-ion concentrations of the media and plant growth. Theoron (6) in recent studies with plants grown in nutrient solutions found the optimum range for peas, barley, and cucumbers was between pH 5.0 and pH 6.0 and that a culture reaction value of pH 4.2 and 4.5 proved

*Conducted at the University of Maryland. The writer is indebted to Dr. Earl Johnston of the University of Maryland for many helpful suggestions in planning the experiment.

markedly injurious. No references have been found in the literature regarding the inter-relation of the growth of spinach in solution cultures and the reaction of the media.

The preliminary part of this project was to determine whether spinach could be grown satisfactorily in water cultures at optimum H-ion concentrations; and the latter part was a study of the inter-relations between plant growth and culture media reactions.

Experiment A

Spinach seed was germinated between filter papers in a moist chamber and grown on a germination net in running tap water until the plants were of sufficient size for transference to the solution cultures.

A type I solution of the following composition was used throughout these studies:

Salt	Partial Volume Molecular Concentration	CC of M/5 Solution per liter
Calcium Nitrate	.005	25
Magnesium Sulphate	.002	10
Dihydrogen Potassium Phosphate	.002	10
Manganous Sulphate	.00002	4.75 cc to 19 1.
Boric Acid	.00002	4.75 cc to 19 1.

Two 19-liter lots of solution, one corrected to a reaction value of pH 6.5 and the other to pH 5.5, were prepared in two 5-gallon glass carboys. Each solution was then transferred to ten, two-quart Mason jars properly covered and fitted with parafinized cork stoppers perforated to hold one plant to each jar. On October 22nd spinach plants were transferred to the jars of nutrient solutions on rotating tables in the greenhouse. The original reaction value of the solution was about pH 5.3.; n/50 N_aOH was added to bring the media to the desired pH readings. Later both solutions changed in the direction of pH 6. This necessitated the addition of sulphuric acid to the lot held at pH 5.5 and sodium hydroxide to that maintained at pH 6.5. The solutions were tested colorimetrically and corrected to the desired pH reading every second day. Two cubic centimeters of a 0.5 per-cent solution of ferric tartrate were added daily to each jar the first month and every three days thereafter. The nutrient solution was changed four times during the course of the experiment.

The plants grew vigorously and by January 16th, the time of their removal from the solution, had attained a size equal to that generally secured in field culture. Both lots grew equally well but that at pH 5.5 had slightly greener foliage and whiter roots than those in the pH 6.5 group. At time of harvest the weight of the green tops was recorded and the roots and tops dried to a constant weight at 80°C. The average weights of dry roots and tops and weights of green tops per plant are given in Table I. The root and top weights of the

plants grown at the two different nutrient media reaction values were almost identical and the differences less than the probable error of the mean.

TABLE I—AVERAGE WEIGHT OF TOPS AND ROOTS OF PLANTS IN EXPERIMENT A

pH Reading of Solution	Average Dry Root Weight (Grams)	Average Top Weight (Grams)	
		Green	Dry
5.5	1.406±.109*	31.55±2.17	4.179±.263
6.5	1.458±.076	30.25±1.51	4.109±.170
	.052±.133	1.30±3.12	.070±.109

*Calculated by Bessels Formula.

$$\text{P. E. M.} = \pm .6745 \sqrt{\frac{\Sigma\, d^2 f}{n\,(n-1)}}$$

EXPERIMENT B

Since the results in Experiment A indicated that spinach was tolerant to an H-ion concentration as high as pH 5.5, it was decided to increase the degree of acidity in the next set of nutrient solutions. Forty, two-quart jars of type I solutions prepared as in Experiment A at H-ion concentrations of pH 4, 4.5, 5.0 and 5.5 were used in Experiment B. The solutions were tested every second day and sufficient n/50 H_2SO_4 was added to change the pH value to the desired point. The solutions were usually about .2 pH higher the second day after corrections. The solutions were changed twice during the experiment. Because of the rapid change in pH value soon after correction, the pH values of the four solutions should be considered as follows: A, 4.0 to 4.2; B, 4.5 to 4.7; C, 5.0 to 5.2; and D, 5.5 to 5.7.

The plants were grown on a germination net in running tap water from November 11th to November 20th when they were transferred to the nutrient solutions of different reaction values. During the first ten days there were no apparent differences in the top growth of the plants in the nutrient solutions, but there was a marked difference in the rate of root growth. The roots in the pH 4.0 solution made a much slower growth than those in the less acid media. The tap root ceased terminal growth after attaining a length of 10 cm. and all later growth occurred near, or slightly above, the surface of the solution. Later a profusion of aerial roots appeared on the tap root one to two centimeters above the solution. The tips penetrated the solution to the depth of approximately one centimeter, turned dark brown, and made no further apical growth. The continued formation of new lateral roots on the tap root, and the branching of the older lateral roots produced a dense clump of root material at the surface of the solution. The roots in the solution at pH 4.5, 5.0, and 5.5 presented a silky, glistening white appearance throughout the entire growth period.

Root length measurements were made on December 13th and 27th, the averages of which are given in Table II.

TABLE II—AVERAGE LENGTH OF ROOTS OF TEN PLANTS

pH Reading of Solution	Average Root Length in Cm.		Increase in Length	
	Dec. 13	Dec. 27	Cm.	Per cent
4.0	9.98± .499	9.05± .517	—	—
4.5	20.97±1.108	27.16±1.079	6.19	29.5
5.0	23.95±1.682	39.75±3.939	15.8	66.1
5.5	29.5 ±1.754	51.3 ±3.517	21.8	73.9

Between December 13th and 27th the roots in the solution at pH 4.0 showed a decrease in length, while those at pH 4.5, 5.0, and 5.5 increased 6.19 per cent, 66.1 per cent, and 73.9 per cent, respectively. The roots branched so profusely after December 27th that careful measurements were no longer possible without seriously injuring them. That the early gain in growth of the roots at pH 5.0 as compared with those at pH 4.5 was not maintained during the later stages of growth is indicated in Table III which shows the dry weights of the roots from these two lots were practically equal.

TABLE III—AVERAGE TOTAL LENGTHS OF SECOND AND THIRD PAIRS OF LEAVES

pH Reading of Solution	Average Total Length in Cm.			Percentage Increase in Growth Based on Growth at pH 4.0	
	Dec. 13	Dec. 27	Jan. 3	Dec. 13	Jan. 3
A. 4.0	17.0±.695	18.6± .708	21.4±6.81	—	—
B. 4.5	24.7±.687	31.1±1.012	36.2±1.092	45.3	69.1
C. 5.0	22.4±.522	32.7±1.041	36.9±1.05	31.8	72.4
D. 5.5	27.0±.789	38.7± .991	46.5±1.38	60.0	117.3

The average total length of the second and third pairs of leaves on December 13th, December 27th, and January 3rd are given in Table III. It was originally planned to secure weekly or bi-weekly measurements of leaf growth which would indicate the comparative rate of development of the different lots throughout the entire growth period. This was discontinued after January 3rd because of the danger of injuring the young leaves which formed compact, nearly sessile, whorls in the center of the plant. The maximum growth rate occurred at pH 5.5 and the lowest at 4.0. The average total length of the third and fourth leaves on January 3rd were 69.1, 72.4, and 117.3 per cent greater at pH 4.5, 5.0, and 5.5 respectively than at pH 4.0. It will be noted that the increase was very marked between pH 4.0 and 4.5 and between 5.0 and 5.5, while the growth rates at 4.5 and 5.0 were nearly equal.

TABLE IV—AVERAGE WEIGHTS OF TOPS AND ROOTS ON JANUARY 16

pH Reading of Solution	Average Weight in Grams per Plant		
	Tops		Roots
	Green Weight	Dry Weight	Dry Weight
A. 4.0	1.92±.202	.290±.021	.175±.002
B. 4.5	8.90±.370	1.006±.036	.246±.008
C. 5.0	9.52±.405	1.053±.038	.250±.009
D. 5.5	12.03±.459	1.388±.057	.316±.010

The green and dry weights of the tops and the dry weights of roots of the plants removed from the solutions on January 16th are given in Table IV. The lowest average weight of tops and roots was secured from the plants grown at a reaction value of pH 4.0, and the highest at pH 5.5. The difference between those secured at pH 4.5 and pH 5.0 were less than the probable error of the difference. A 281 per cent increase in the dry top weight and 108.4 per cent increase in dry root weight occurred with a decrease of pH .5 in acidity from pH 4.0 to pH 4.5. In the gradient from pH 5.0 to pH 5.5 there occurred significant increases of 31.8 per cent and 26.4 per cent for dry weights of tops and roots respectively.

TABLE V—INCREASE IN DRY WEIGHT OF ROOTS AND TOPS FOR EACH 0.5 PH DECREASE IN ACIDITY

pH Reading of Solution	Dry Weight of Tops		Dry Weight of Roots	
	Increase		Increase	
	Grams	Per cent	Grams	Per cent
B. 4.5	.716±.042	281.3	.1285±.0082	108.4
C. 5.0	.047±.052	4.7	.0035±.012	1.4
D. 5.5	.335±.067	31.8	.0660±.013	26.4

CONCLUSION

There is apparently a definite inter-relation between the reaction of the nutrient solution and the growth of spinach. In the experiments here reported the lower pH limit of optimum growth was near pH 5.5. The upper limit beyond pH 6.5 was not determined because at less acid reactions part of the nutrient salts precipitated from the solution.

The use of an excessively acid nutrient solution, at a reaction value of pH 4.0 resulted in a rapid discoloration and thickening of the roots and cessation of terminal growth of all submerged portions, followed by the formation of lateral aerial roots 1 to 2 centimeters above the surface of the liquid. The death of the root hairs and rootlets may have been due to the precipitation of the root cell protoplasm at its isoletric point. Addoms (7) noted similar injury to wheat roots grown in a very acid media and was able by use of a dark field illumination to detect coagulation of the cell protoplasm.

LITERATURE CITED

1. BURGESS, PAUL S., and PEMBER, F. R. Active aluminum as a factor detrimental to crop production in many acid soils. R. I. Expt. Sta. Bul. 194. 1923.
2. ZIMMERLEY, H. H. Soil acidity in relation to spinach production. Va. Truck Expt. Sta. Bul. 57. 1926.
3. SALTER, R. M., and MCILVAINE, T. C. Effect of reaction of solution on germination of seeds and growth of seedling. Jour. Agr. Res., 19:73–95. 1920.
4. HOAGLAND, D. R. The relation of the plant to the reaction of the nutrient solution. Science, N. S. 48: No. 1243, 422–425. 1918.
5. MCCALL, A. G., and HOAG, J. R. The relation of the hydrogen-ion concentration of nutrient solutions to growth and chlorosis of wheat plants. Soil Sci., 12:69–77. 1921.
6. THERON, J. J. Influence of reaction on inter-relations between plant and its culture media. Univ. of Calf. Pub. in Ag. Sci., 4:413–444. 1924.
7. ADDOMS, RUTH M. The effect of the H-ion on the protoplasm of the root hairs of wheat. Am. Jour. Bot., 10:211–219. 1922.

The Effect on Yield of Sprout Removal from Potato Seed Tubers[1]

By K. C. WESTOVER, *West Virginia University, Morgantown, W. Va.*

THERE are very few potato growers in West Virginia who have specially constructed storage houses or cellars in which to hold potato seed stock. Some purchase a fresh supply of seed stock each season from the North, but the majority of the growers hold over their seed stocks out-of-doors in "pits" or "piles" or in the ordinary farm cellars. In either case there is generally scant opportunity for effective control of the temperature or humidity and almost invariably sprouting occurs during the latter part of the storage period. The removal of these sprouts is commonly practiced.

Experiments were run in 1921–22 and 1922–23 at the West Virginia Agricultural Experiment Station, to determine the effect on yield of sprout removal from improperly stored seed potatoes. Since results were so similar in the two seasons only data obtained in 1922–23 are included in this paper. Smooth or white Rural seed stock from the farm of J. J. Betler of Pickens, West Virginia, was used. This strain of seed stock was produced at an altitude of about 2400 feet and had been selected for several years.

On December 22, 1922, seven lots of 150 tubers each were selected for the tests. Two of these lots were placed in a single layer on a shelf in cold storage and held at a temperature of 39 degrees F. and a relative humidity of approximately 85 per cent, to serve as check seed stock. The remaining five lots were placed in an adjacent tool room to sprout under poor storage conditions. A thin layer of shavings was spread on the concrete floor and covered with disinfected burlap. The potatoes were arranged in a single layer upon this, and covered with more burlap to exclude the light. Here the temperature sometimes varied as much as 15 degrees in 24 hours with an average temperature of about 65 degrees F. The relative humidity varied from about 25 to 60 per cent, the average being about 35 per cent. Several times during the storage period the tool room floor became wet. When the sprouts had grown to a length of ½ to 1 inch they were removed by rubbing with the hands. One lot was placed in cold storage to prevent further sprouting. The other four lots remained in poor storage to sprout again.

When the sprouts were ½ to 1 inch long they were removed and another lot was placed in cold storage to prevent further sprouting. This procedure was followed until all five lots were in cold storage. The field planting was made April 22, the day after the last lot had been "rubbed." The tubers were quartered lengthwise. These seed pieces were dropped at intervals of 12 inches and covered by hand. Nine tubers (36 hills) of a lot were planted in a row. The space between the rows was 36 inches.

[1]Published with the approval of the Director as paper No. 73 of the Journal Series of the West Virginia Agricultural Experiment Station.

The planting sequence of the different seed lots was in the order of the number of times the sprouts had been removed and a check row planted from the seed stock held "unsprouted" in cold storage occurred every third row, as follows:

Row 1. Check—unsprouted
Row 2. Lot 1—Sprouts removed once
Row 3. Lot 2—Sprouts removed twice
Row 4. Check
Row 5. Lot 3—Sprouts removed three times
Row 6. Lot 4—Sprouts removed four times
Row 7. Check
Row 8. Lot 5—Sprouts removed five times
Row 9. Lot 1
Row 10. Check—etc.

By this arrangement each "treatment" was flanked on either the right or the left by a check row. This series was replicated fifteen times. The planting was bounded by "guard rows" planted with check seed stock.

About six weeks after planting, when all the plants had come through, a "stand" count was made and observations taken on the comparative vigor of the plants from the different lots of seed stock.

At harvest the guard rows and about two feet from each end of each row were discarded from the test plots to eliminate "border influence." Each row was graded and the weights of the primes and the total yields were taken to within one-tenth pound.

Table I gives the dates on which the sprouts were removed, the number of days elapsing between sprout removal or the time required for them to acquire a length of ½ to 1 inch and the percentage of tubers lost in each lot during the storage period. It will be noted that as the season progressed the period elapsing between sprout removals decreased, however the decrease was not rapid after the first and second periods. Apparently the rest period was nearing its close and life processes inside the tuber were quickening.

Withering did not occur to any considerable extent until the second sprouting period. There was a marked wilting and reduction in size after this time. The sprouts also became more spindling with each successive sprout removal.

The percentage of tuber loss from decay increased in about the same proportion as the periods between sprout removal decreased. This suggests that with the close of the rest period the permeability of the skin to micro-organisms apparently increased. It is possible that the removal of sprouts contributed to this condition.

In the last column of Table I the difference in per cent of stand between the different lots of tubers which have been subjected to sprout removal and the unsprouted check stock is given. These data are based on the average of 16 systematically distributed plot rows of each treatment. The first four sprout removals are shown to have rapidly lowered the stand. The fifth rubbing apparently had little effect. The comparative vigor of the plants of the various lots was

TABLE I—DATES OF SPROUT REMOVAL, TIME LAPSING BETWEEN SRPOUT REMOVAL, STORAGE LOSSES AND PLANT "STANDS" OF SEED TUBERS FROM WHICH THE SPROUTS WERE REMOVED A VARYING NUMBER OF TIMES

Lot Number	Treatment	Date When Lots Were Placed in Poor Storage	Date When Lots Were Placed in Cold Storage	Days Lapsing Between Sprout Removal	Percent Loss in Storage	Percent Increase in Stand of Check Stock
6 and 7	Check, unsprouted		Dec. 21, 1922	—	1.3	—
1	Sprouts removed once	Dec. 21, 1922	Feb. 7, 1923	48	6.0	23.0
2	Sprouts removed twice	Dec. 21, 1922	Mar. 5, 1923	26	11.3	41.4
3	Sprouts removed three times	Dec. 21, 1922	Mar. 22, 1923	16	16.0	46.7
4	Sprouts removed four times	Dec. 21, 1922	Apr. 6, 1923	14	16.0	67.2
5	Sprouts removed five times	Dec. 21, 1922	Apr. 20, 1923	14	16.6	68.7

noted at the time the stand data were taken. The vigor of the stock having had the sprouts removed once was decidedly lower than that of the check. The plants from tubers "rubbed" twice and three times were also correspondingly weaker. The few plants from the last two lots of treated seed stock were without exception extremely unthrifty.

The data covering storage loss and that taken on stand together with the information obtained from observations on plant vigor are closely substantiated by the yield data. Table II gives the results of a comparison by Student's Method of the yields of the variously treated stocks with those of the nearest check or unsprouted stock.

In the above table the comparisons of the yields of primes and the total yields of the various lots are made with those of the check seed stock using the entire planting. In addition similar comparisons are made by first causing the original series and the first seven replications and then by using the last half of the planting. The comparisons embracing the two divisions are made with the idea of showing to what extent inconsistencies might occur which do not appear when the data of the whole planting is considered.

The first analysis of yields in which the entire planting is used indicates that the removal of sprouts once tends to cause a reduction in the yield of prime potatoes and the total yield, however not sufficiently so to be significant. When the sprouts were removed two or more times the reduction in yield is significant. The comparison of the yields of the first half of the plantng show a slight but insgnificant increase in yield of prime tubers and of the total yield with the sprouts removed once but in all other cases the effects were significantly negative. This slight positive difference in yield cannot be considered important in view of the preponderance of negative significant differences. The comparison of the yields of the remaining half of the planting gave significant negative results in all cases.

The data obtained from this experiment as here interpreted show quite conclusively that the practice of removing sprouts from improperly stored potato seed stock increases the loss in storage from decay, reduces the stand of plants in the field and lowers their vigor and decreases the yield of prime tubers and the total yield. Mention is made of the similar results obtained in the season 1921–1922. In view of the clear cut results obtained, it is questionable if tubers which have had the sprouts "rubbed" from them more than once are of much value as seed stock.

TABLE II—THE YIELD FROM UNSPROUTED OR CHECK TUBERS COMPARED WITH THOSE FROM TUBERS HAVING HAD THE SPROUTS REMOVED A VARYING NUMBER OF TIMES BY STUDENT'S METHOD

	Tuber Lot No.	Treatment Compared with Check	Section of Planting Used	Summation of differences in Yield in Pounds	Summation of Yield Differences Squared	Value	Odds in Favor of Check Seed Stock
Primes	1	Sprouts removed once	Entire	— 18.50	129.76	—0.419	14.9:1
			First half	+ 0.90	52.69	+0.493	—7.5:1
			Last half	— 17.60	77.07	—1.117	94.0:1
	2	Sprouts removed twice	Entire	— 59.50	385.59	—1.161	3,665.4:1
			First half	— 27.50	198.97	—0.951	47.8:1
			Last half	— 32.00	186.62	—1.478	342.0:1
	3	Sprouts removed three times	Entire	— 71.30	533.49	—1.214	4,999.0:1
			First half	— 30.20	228.36	—0.998	59.2:1
			Last half	— 41.10	305.13	—1.500	369.0:1
	4	Sprouts removed four times	Entire	— 88.15	614.88	—1.949	>10,000.0:1
			First half	— 33.85	197.23	—1.628	563.4:1
			Last half	— 54.30	417.65	—2.742	>10,000.0:1
	5	Sprouts removed five times	Entire	—100.00	764.80	—2.114	>10,000.0:1
			First half	— 36.90	205.09	—2.208	3,332.0:1
			Last half	— 61.10	559.71	—2.834	>10,000.0:1
Total Yields	1	Sprouts removed once	Entire	— 27.00	213.06	—0.524	30.7:1
			First half	+ 3.50	46.78	+0.184	—2.1:1
			Last half	— 30.60	166.28	—1.542	421.0:1
	2	Sprouts removed twice	Entire	— 64.15	445.49	—1.199	4,999.0:1
			First half	— 24.15	165.50	—0.887	38.4:1
			Last half	— 40.70	279.99	—1.685	688.2:1
	3	Sprouts removed three times	Entire	— 75.25	615.17	—1.164	3,665.4:1
			First half	— 25.05	198.50	—0.808	27.9:1
			Last half	— 50.20	416.67	—1.760	865.4:1
	4	Sprouts removed four times	Entire	—104.26	923.27	—1.669	>10,000.0:1
			First half	— 42.26	311.05	—1.595	507.8:1
			Last half	— 62.00	612.22	—1.910	1,248.8:1
	5	Sprouts removed five times	Entire	— 29.30	1236.87	—2.332	>10,000.0:1
			First half	— 47.30	318.57	—2.683	>10,000.0:1
			Last half	— 82.00	918.30	—3.286	>10,000.0:1

Tomato Quality as Influenced by the Amount of Outer and Inner Wall Region

By J. H. MacGillivray and O. W. Ford, *Purdue University, Lafayette, Ind.*

Effects of Temperature on Seeding in Celery

By H. C. Thompson, *Cornell University, Ithaca, N. Y.*

Floral Development in *Daucus carota*

By H. A. Borthwick, Mabel Wiesendanger, and W. W. Robbins, *University of California, Davis, Calif.*

Effect of Temperature and Rest Period Upon Seed-Stock Development in Mature Cabbage

By J. C. Miller, *University of Oklahoma, Stillwater, Okla.*

Physiological Shrinkage of Sweet Potatoes in Curing

By W. D. KIMBROUGH, *Experiment Station, Auburn, Ala.*

SWEET potatoes shrink considerably during the curing process. Thompson and Beattie (3) found that for four years the average loss of the Porto Rico variety was 7.1 per cent. They attributed the shrinkage to loss of moisture. Johnstone (1), however, found that the change in moisture content in the curing process was very slight. He seems to attribute the shrinkage largely to respiratory activity and states that water loss at curing time seems to have been overestimated.

The work reported here was done to determine for the Porto Rico variety the shrinkage in curing caused by loss of moisture and that resulting from loss of solids.

Sweet potatoes were dug and taken immediately to the laboratory. Samples for moisture determinations were taken within two hours. Representative samples were selected, weighed and put into containers for making respiration determinations. These potatoes were kept at a constant temperature of 30°C. during the curing period. Dry air was drawn over some samples and calcium chloride was placed in the containers to insure a dry atmosphere. No attempt was made to keep the atmosphere around other samples dry and in these cases it was moist. After the curing period, which lasted about two weeks, potatoes were removed from the constant temperature chamber, reweighed and samples taken for moisture determinations.

TABLE I—SHRINKAGE IN SWEET POTATOES KEPT AT 30°C.

Air Surrounding Sample	Per cent Moisture Content		Per cent Total Shrinkage	Per cent Loss of Solids, As Glucose	
	Oct. 20, 1927	Nov. 4, 1927		Fresh Weight	Dry Weight
Dry.......	65.87	64.6	5.70	0.96	2.81
Moist......		67.0	0.66	0.92	2.70
	Nov. 30, 1927	Dec. 16, 1927			
Dry.......	74.27	71.77	6.86	1.00	3.88
	Oct. 20, 1928	Nov. 5, 1928			
Dry.......		65.80	6.11	0.94	2.84
Moist......	66.90	67.83	1.00	0.85	2.57
Dry.......		65.68	6.63	0.92	2.78
Moist......		67.40	0.84	0.90	2.72

Total shrinkage was determined by loss in weight. Moisture content was determined by drying samples of grated potatoes in a vaccuum oven at 80°C. to constant weight. Loss of solids was calculated from the CO_2 of respiration which was measured for the entire curing period. Respiration was determined by the method previously described by the writer (2).

The results obtained clearly show the relative amounts of moisture and of solids lost during the curing process. The shrinkage is due largely to loss of moisture. This is true even though the percentage

moisture content may decrease only slightly compared to the total shrinkage. The loss of solids however due to respiration during curing is not a negligible amount. A loss of about 1 per cent fresh weight or nearly 3 per cent dry weight is considerable for material that keeps well.

Very little difference was found in the loss of solids due to variation in the humidity of the atmosphere. There was a slight increase in moisture content in potatoes kept in a moist atmosphere.

Attention is called to the variation in moisture content in sweet potatoes both at time of digging and after curing.

Literature Cited

1. Johnstone, George R. Physiological study of two varieties *Ipomoea batatas.* Bot. Gaz., Vol. LXXX, No. 2. 1925.
2. Kimbrough, W. D. A study of respiration in potatoes with special reference to storage and transportation. Md. Agr. Exp. Sta. Bul. 276. 1925.
3. Thompson, H. C., and Beattie, J. H. Sweet potato storage studies. U. S. D. A. Bul. No. 1063. 1922.

Ethylene Ripening of Tomatoes in Relation to Stage of Maturity

By PAUL WORK, *Cornell University, Ithaca, N. Y.*

WE are indebted to Harvey for bringing before us the possibilities of ethylene and other gases for hastening the maturity of various fruits and vegetables. Rosa studied the application of ethylene ripening to the tomato. Growers and companies engaged in the ripening and repacking of tomatoes have made effective use of gases, finding tangible results in the shortening of time and also in the improvement of quality as compared with untreated stock.

The present inquiry is concerned, first, with finding a measure for the progress of ripening of tomatoes; second, with a study of the influence on ripening of stage of maturity at time of picking and treating and; third, with the gains in time realized by the use of gas.

Informal trials in October, 1927, showed saving in time of ripening when gas was used. In the spring of 1928, a crop of greenhouse tomatoes was grown using 22 plants each of Bonny Best, Avon Early (of the Earliana group), Globe, and Marglobe and 11 plants each of Gulf State Market and Stone. Beginning April 17, about 30 flowers of each of the first four varieties and 15 flowers of each of the others were hand pollinated thrice a week, and a dated tag fastened to each blossom.

On June 7, six lots of tomatoes were picked, each lot representing a single blossoming date as indicated by the tags. About 20 fruits made up each lot, but the Gulf State Market and Globe seldom yielded over 12 of a given date. Each lot was sorted into two parts as nearly alike in size and color as possible.

Two basement rooms were used for the treatments. One room of about 1000 cubic feet received ethylene gas at the rate of 1 cu. ft. daily. The other room was untreated. Temperature averaged about 80°F. and humidity about 70 per cent in both rooms as recorded by hygro-thermographs. Electric heaters were used for temperature control and water was evaporated from the heaters and also sprayed on the walls to maintain humidity.

Each room received tomatoes of six blossom dates from each of six varieties. The stage of maturity was observed by eye, and records made from day to day of the number of fruits which were classified as ripe, half-ripe, turning, and green. The same experiment was repeated beginning June 14 with fruits from all six varieties and of four blossom dates.

The resulting array of figures offered a puzzling problem for analysis. We stand in need of a quantitative measure of stage of ripening, but in its absence an arbitrary plan of rating was adopted. The count of ripe tomatoes was multiplied by 4; of half-ripe, by 2; of turning, by 1; and of green, by 0. Where fruits were nearly ripe or

softening, but not well colored, they were rated at 3. Some of these developed to full ripeness in a day or two and others never acquired full color. The total of these figures, reduced to a basis of 10 fruits and added for each lot, gives a value which we may call a "ripening index." This we do with full realization of its crudity and only in the hope that it may prove better than a simple statement that one lot ripened faster than another.

The ripening indices as thus calculated are plotted on the accompanying chart including all varieties. The data are not regarded as conclusive. We have no suitable measure of market maturity in tomatoes and we are even more seriously hampered for lack of a measure for mature-green and immature-green fruits. Fairly careful study of the color (whitish green and deep green) and also of the browning of the outer ring of the abscission scar failed to suggest that these are reliable. The number of days from blossom which is used in this study has been shown to be unreliable by workers at the Cheshunt Station in England and by Haber. This is not surprising as it is entirely probable, in fact, evident, that some fruits have a much shorter growth period than others, development being perhaps held in abeyance in some and going forward in others according to the balance of internal nutritional conditions. At the same time, the data here offered suggest that days from blossoming is perhaps our best guide at present.

In these experiments we should have had more plants and more fruits. There should also be repetitions in the form of a larger number of duplicate lots and perhaps the use of duplicate rooms. The present data do not seem to afford opportunity for probable error methods and so are in this respect far from ideal.

The data suggest certain deductions as follows:

(1). In spite of obvious faults we seem to have no better experimental guide as to stage of maturity of green tomatoes than time from blossoming. An index of ripening based on classification by eye and the use of arbitrary factors seems helpful as a measure of maturity.

(2). Ethylene gas is more effective in hastening the ripening of fruits of the age of 30 to 40 days from blossom than of either older or younger fruits. The gas will not make good tomatoes out of very immature fruit.

(3). The maximum gains amount to 3 to 4 days. This is less than in some commercial experience but is probably not far from average.

(4). The data do not show any clear-cut advantage of one variety of those tested over another in response to ethylene gas.

Commercial users of ethylene for tomatoes say they are finding it of value as much in securing a high-quality product as in hastening ripening. The extent to which that is due to the gas and extent to which it is due to intelligent sorting and skillful control of temperature and humidity is a subject calling for investigation.

TABLE I—RIPENING INDICES FOR TOMATOES OF VARIOUS STAGES OF MATURITY BY DAYS FROM PICKING, UNDER ETHYLENE AND NO ETHYLENE TREATMENTS. SIX VARIETIES INCLUDED

Experiment I

Days From Blossoming	Days Under Treatment														
	0	2		3		4		5		6		8		9	
		G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
47	64	163	138	203	170	212	192	217	199	221	211	231	228		
45	40	124	123	166	162	178	176	197	188	209	208	218	230		
43	13	68	61	111	101	134	132	161	158	188	183	204	215		
38	0	15	7	39	17	74	37	121	64	154	86	214	169		
31	0	0	0	0	0	1	0	25	0	45	0	95	1	126	13
26	0	0	0	0	0	0	0	0	0	0	0	25	0	28	0

Experiment II

Days From Blossoming	Days Under Treatment																
	0	2		4		5		6		7		8		9		11	
		G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG	G	NG
43	18	45	43	109	98	131	116	174	150	189	164	197	181	198	190	207	195
41	7	33	18	82	63	103	82	159	119	167	148	177	168	186	178	196	190
36	0	0	0	58	1	80	22	117	46	149	83	167	123	172	160	176	172
29	0	0	0	8	0	21	0	47	0	76	3	112	6	124	34	179	114

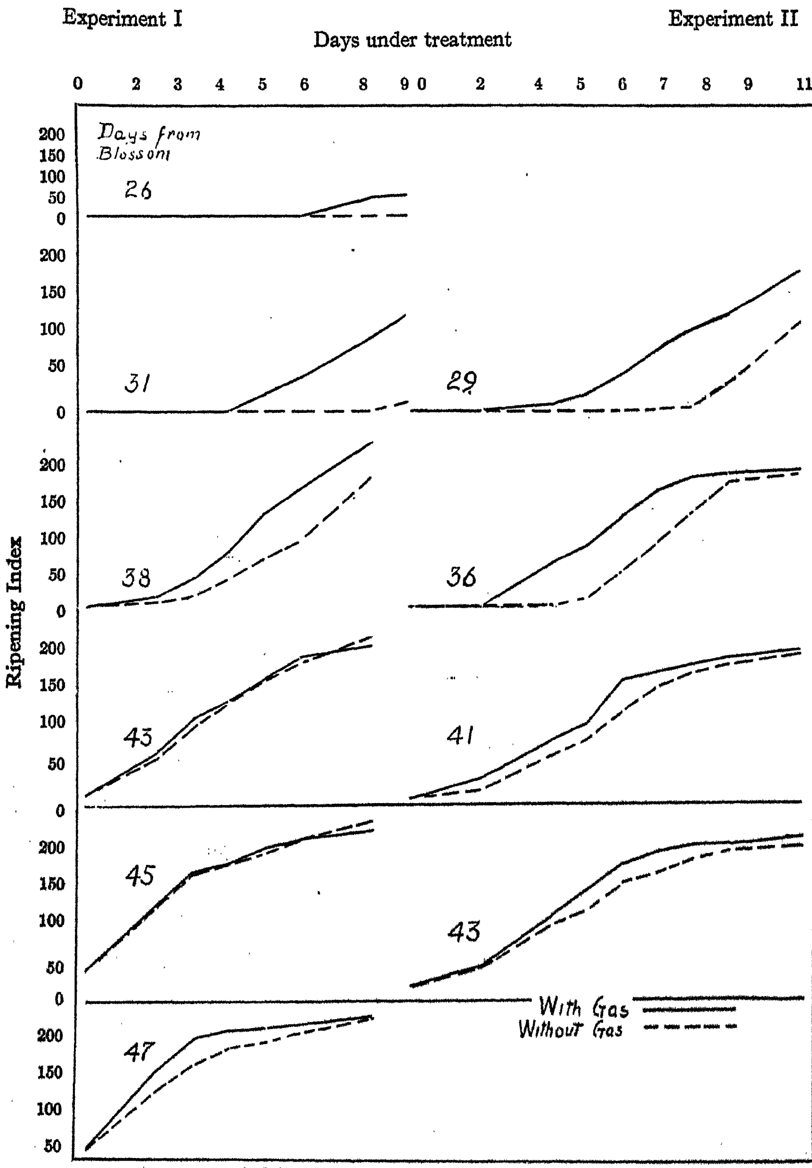


FIG. 1. Comparison of ripening of tomatoes of various stages of maturity under "ethylene" and "no ethylene" treatments. Ordinates represent number of days from picking and beginning of treatment. Abscissas represent ripening index as described in text. Solid line represents ethylene treated fruits; broken line, ripened without gas. Figures with each graph represent number of days from blossoming to picking. Six varieties included.

LITERATRUE CITED

1. ROSA, J. T. Ripening of tomatoes. Proc. Am. Soc. Hort. Sci., 315–322. 1925.
2. ————. Ripening and storage of tomatoes. Proc. Am. Soc. Hort. Sci., 233–242. 1926.
3. CORBETT, W. The blooming and fruiting period of the tomato plant. 13th Annual Report (1927) Cheshunt Experiment and Research Station, pp. 87–94. 1928.
4. HABER, E. S. Influence of soil reaction on ionizable constituents of the tomato. Jour. Agr. Res., 37:101–114. 1928.

The Effects of Ether and Various Temperatures In Forcing Rhubarb

By J. R. HEPLER, *University of New Hampshire, Durham, N. H.*

THE effects of ether in forcing various plants have been studied by a number of investigators. Among the first workers was Johannsen (3) who studied its effects on lilacs and other hard wooded plants. His results showed that etherized plants bloomed from two to three weeks earlier than unetherized plants in the early part of the rest period, but very little earlier in the later part of the rest stage. Lilacs and other hard wooded flowering shrubs, forced commercially in France and Germany, are etherized to bring them into bloom earlier, especially for the holiday market.

Stuart (6) used 10 cc of sulphuric ether per cubic foot for 48 hours, as an aid in forcing rhubarb and increased the yield of the first picking 95.3 per cent; of the second picking 45.7 per cent; and of the third picking 7.3 per cent; with an average of 35.5 per cent for the first three pickings. The total yields were 1671 grams for the etherized clumps and 1419 grams for the untreated ones, or 17.7 per cent in favor of the treated roots.

Later Stuart made six plantings of etherized and unetherized rhubarb on the following dates: November 1, November 4, December 4, January 4, January 20, and February 15. The first two lots were unfrozen and did not grow until the latter part of March. Apparently unfrozen roots will not make any growth until the normal time for outdoor rhubarb to grow and even then the growth is very feeble. The increase in favor of the etherized rhubarb was 21 per cent for the roots set out December 4; 70 per cent for the ones of January 4; and 54 per cent for those of January 20th. No data were taken on the February 15 planting because it was so late in the season that there was no increased growth from etherization. His conclusions were as follows: "(1) Etherization of rhubarb plants for winter forcing results in an increased yield; (2) Freezing the rhubarb clumps is a necessary process in forcing; (3) Etherization will not take the place of freezing."

Coville's (1) work with woody plants also shows the necessity of freezing to break the rest period. He found that blueberry plants would not grow until they had gone through a rest period and that unless the plants were frozen the growth was very weak. He states that the growth is caused by a change of starch into sugar. The theory advanced by Coville in explanation of this process is as

follows: "The starch grains stored in the cells of the plant are at first separated by the living and active cell membranes from the enzyme that would transform the starch into sugar, but when the plant is chilled, the vital activity of the cell membrane is weakened so that the enzyme "leaks" through it, comes in contact with the starch and turns it into sugar."

Hammersly (2) secured increases in yield of rhubarb by etherization as follows: one-year-old roots 0 per cent; two-year-old roots 21 per cent; three-year-old roots 126 per cent; four-year-old roots 67 per cent; and five-year-old roots 21 per cent. Chloroformed roots showed very little increase in growth. Etherized unfrozen roots did not make any growth until late March.

Vorhees (8) concluded that etherization did not increase the total yield but that the percentage of marketable stalks was larger in the etherized roots.

Effects of Ether on Forcing Rhubarb

The roots used in this experiment were etherized in an air tight box with a capacity of 54 cubic feet. These were thawed just before etherization with the exception of one lot which was etherized while frozen. The commercial grades of sulphuric ether were used at the rate of 10cc, 15cc, and 20cc per cubic foot of box space, the space occupied by the roots being disregarded. The exposures were for 24 and 48 hours.

In the etherization tests one-and three-year-old Linneaus, and one- and two-year-old Mammoth roots were used. The data recorded were number of stalks per picking, weight in grams of the stalks and leaf blades, and the weight of the stalks with the leaf blades removed. Twenty roots were used in each test.

The effect of ether in accelerating the growth of the rhubarb is very pronounced as may be noticed in the results of the first two pickings. On the third picking, or after 37 days, the effects of the ether have disappeared. There is very little difference in the final yield of the different plots although the larger quantities of ether for the shorter periods seem to give the better results.

The effects of etherization are more pronounced in three-year-old roots than in one-year-old roots, and the longer exposure is more effective, probably because of the larger roots and the smaller dosage.

The effects of ether in hastening maturity can be seen in Plot 42 where the first picking was almost three times as large as that from the check plot. The yield of each separate picking up to the fifth was higher, and the final total 49 per cent more than the check.

Disease appeared in Plot 44 between the fourth and fifth picking, reducing the yield after the fifth picking. Even so, the smaller dosage for the shorter period shows increases in yield of 33, 27, 11 and 12 per cent respectively for the first four pickings.

The one year old Mammoth roots seemed to vary a great deal in productiveness and the check is probably not a fair test of the yield of unetherized rhubarb. It is surely sufficiently high since the total yield of a sand plot in the same house was only two-thirds of the

TABLE I—EFFECTS OF ETHERIZATION ON YIELD AND RATE OF MATURITY ON ONE-YEAR-OLD LINNAEUS ROOTS

Plot No.	Treatment per cu. ft.	Total Yield in Grams for Each Picking							
		18 Days	Per cent Increase	24 Days	Per cent Increase	31 Days	Per cent Increase	Total	Per cent Increase
53	15cc 48 hrs.	4021	82.8	8294	43.7	11719	1.3	14922	—2.7
54	15cc 24 hrs.	4452	102.3	9277	60.7	12962	12.0	16302	6.3
66	20cc 48 hrs.	4805	118.4	9335	61.7	11200	—3.1	14798	—3.5
69	20cc 24 hrs.	3850	75.0	7570	31.1	12210	5.5	18025	17.5
43	check	2200	—	5770	—	11572	—	15337	—

TABLE II—EFFECTS OF ETHERIZATION ON YIELD AND RATE OF MATURITY ON THREE-YEAR-OLD LINNAEUS ROOTS

Plot No.	Treatment per cu. ft.	Total Yield in Grams for Each Picking							
		18 Days	Per cent Increase	24 Days	Per cent Increase	31 Days	Per cent Increase	Total	Per cent Increase
42	10cc 48 hrs.	16371	177.7	24436	125.3	29756	82.7	38216	49.1
44	10cc 24 hrs.	7810	32.5	13785	27.1	17995	10.5	23895	—6.7
45	check	5895	—	10845	—	16285	—	25638	—

TABLE III—EFFECTS OF ETHERIZATION ON YIELD AND RATE OF MATURITY OF ONE-YEAR-OLD MAMMOTH ROOTS

Plot No.	Treatment per cu. ft.	Total Yield in Grams for Each Picking									
		21 Days	Per cent Increase	29 Days	Per cent Increase	35 Days	Per cent Increase	43 Days	Per cent Increase	Total Yield	Per cent Increase
63	15cc 24 hrs.	5130	95.8	9090	7.4	13240	5.2	16215	5.3	23430	22.4
64	20cc 48 hrs.	7720	194.6	13470	59.1	16345	29.8	19620	27.5	23010	20.2
68	20cc 24 hrs.	2425	—7.5	6425	—24.1	10685	—15.1	13470	—12.5	17335	—9.5
24	check	2620	—	8465	—	12590	—	15390	—	19135	—

check plot and that of the variety plot in a cooler house about four-fifths of its yield. However, the acceleration in growth is seen very plainly by the increases in plot 64, which were respectively 195, 60, 30, and 28 per cent larger in the first four pickings than the check. The results on these roots differ from the one-year Linneaus where the larger amounts of ether had an injurious effect. However, the Mammoth roots were larger and had more soil on them when they were etherized, and it is possible that the ether did not act as effectively on the Mammoth roots as on the Linneaus.

Plot 49 was etherized while frozen and the final yield was quite similar to plot 62, which was etherized for 24 hours. It was earlier than plot 62, probably because it took less than 24 hours to thaw the roots and ether had a greater effect than on plot 62.

The results on etherization of two-year-old Mammoth agree with those of one-year-old Linneaus when the yield was larger from the shorter exposures.

Effects of Temperature on Forcing Rhubarb

Morse (4) states that the best yields, best color, best quality, and best texture in rhubarb are to be had when it is grown at a temperature ranging from 50° to 60° F. At temperature lower than 50°F. the growth will be very slow; higher than 60° the growth will be fast but the texture poor. Hammersly (2) says that there is little difference in yield but agrees substantially with Morse in regard to the other points.

Sayre (5) states that temperature affects both the yield and color of forced rhubarb. The lower the forcing temperature, the slower the growth and the more red or pink in the stalks. At 59° F. maximum yields of well-colored stalks were obtained. An earlier crop of inferior color and lighter yield was produced at 68° F. Slow growing, dark red stalks, and a light yield were produced at 50° F. No stalks were obtained at 72° F. or over.

There were seven plots of two-year-old Victoria roots in the temperature test. Three of these plots, Nos. 61, 21 and 5, were under greenhouse benches; two of them, Nos. 81 and 83, were in the basement of the greenhouse; one, No. 85, in a bulb cellar; and one, No. 87, in an unheated cellar of a dwelling house. Plots 81 and 83 were set on concrete. The moisture content of the air was very low for these two plots, which together with high temperature favored development of root rot.

The temperatures were taken with a centigrade thermometer, between eight and nine o'clock in the morning. The soil readings were taken three inches below the surface of the soil and the air readings about five feet above the surface.

The rate of growth of forced rhubarb is directly proportional to the temperature, and the first few pickings are not greatly affected by other growth factors. The soil temperature of plot 61 should have averaged higher than plot 21 on account of the higher air temperature. The soil covering of plot 61, which contained a much higher percentage of clay than plot 21, had a higher water holding capacity and consequently a lower temperature.

TABLE IV—EFFECTS OF ETHERIZATION ON RATE OF MATURITY AND TOTAL YIELD OF TWO-YEAR-OLD MAMMOTH ROOTS

Plot No.	Treatment per cu. ft.	Total Yield in Grams for Each Picking									
		17 Days	Per cent Increase	21 Days	Per cent Increase	28 Days	Per cent Increase	42 Days	Per cent Increase	Total Yield	Per cent Increase
49	15cc (F) 48 hrs.	2072		8122	64.9	18007	23.1	28072	12.2	33594	13.6
51	15cc 48 hrs.	985		5585	13.4	12715	—13.1	19865	—20.6	22862	—22.6
62	15cc 24 hrs.	1010		4635	—5.9	12085	—17.3	24835	—0.7	34252	15.9
65	20cc 48 hrs.	1275		8665	75.9	14679	0.4	22375	—10.6	25720	—13.1
67	20cc 24 hrs.	4380		14960	203.8	24555	67.9	34576	38.2	46121	56.0
46	check	——		4925	——	14625	——	25015	——	29565	——

TABLE V—EFFECTS OF TEMPERATURE ON YIELD AND RATE OF MATURITY OF TWO-YEAR-OLD VICTORIA RHUBARB ROOTS

Plot No.	Temperature F.		Total Yield in Grams for Each Picking								
	Air	Soil	23 Days	32 Days	46 Days	63 Days	80 Days	100 Days	128 Days	Per cent of Highest Plot	Av. Wt. per Stalk, grams
83	62.7± .9	61.7± .6	5177	8572	11542	12989	13169	13169	13169	31	28.8
81	62.7± .9	59.9± .6	4146	11381	15694	19169	20441	20441	20441	48	23.7
21	63.5± .4	57.2± .2	3225	11155	20990	25670	26920	27175	27175	64	31.9
61	66.2± .5	56.3± .3	2443	15088	30923	38978	42024	42553	42553	100	32.3
5	58.0± .8	53.6± .3		4645	13523	20115	22835	24250	24250	57	35.2
85	51.8±1.2	42.2±1.0			13900	24600	28915	32535	32535	79	31.4
87	45.5± .5	40.6± .7						5138	11490	52	41.2

The average weight of the leaf stalks is considerably higher in the lower temperatures. Thus plots 81 and 85 are directly comparable because the only growth difference was the temperature. In plot 81 the leaf stalks averaged 23.7 grams; and in plot 85, 31.4 grams, or approximately one-third larger.

The effects of temperature upon the rate of maturity were as follows; at the end of forty days 83 per cent of the crop of plot 83 was harvested; 70 per cent of plot 81; 62 per cent of plot 21; 58 per cent of plot 61; 41.5 per cent of plot 5, and 19 per cent of plot 85.

The plants in the unheated house cellar, No. 87, did not start growing until the temperature reached 45° F. and then grew so slowly that the first picking was made 100 days after setting out the roots, or about the same time that the first picking was made out doors. The rhubarb produced in this plot was of a bright shade of pink, and the stalks were large and very firm.

The conclusions regarding temperature and humidity may be stated as follows: A humid atmosphere and a high temperature produce a heavy crop of rhubarb as in the case of plot 61, while a dry atmosphere and a high temperature produce a low yield as in the case of plots 81 and 83. A soil temperature of 56° to 58° F. and an air temperature of 60° to 65° F. will mature approximately 65 per cent of the crop within six weeks after planting, while a soil temperature of 50° to 53° F. and an air temperature of 56° to 58° F. will mature about 50 per cent of the crop in the same time. A temperature of 48° to 52° F. is too low for commercial forcing unless the rhubarb is not wanted until eight weeks after planting time. If the temperature is under 48° F. the growth is so slow that the rhubarb develops only a short time before the out door product is ready.

The color of forced rhubarb is an important factor in marketing. A dark red color is preferred, although a pink is very desirable. Color depends on two factors, heredity and temperature. If a good red strain of rhubarb is planted, such as the best strains of Victoria or Linneaus, the forced product will be red whatever the temperature, but in the average strain the pink color will develop only in temperatures below 55° F. Where the natural color of the rhubarb is green, as in the Mammoth, low temperatures will not develop the pink color.

Literature Cited

1. Coville, F. V. The influence of cold in stimulating the growth of plants. Jour. of Agr. Res., 20 No. 2, 1920.
2. Hammersly, R. W. Experiments in forcing rhubarb. Unpublished thesis, University of Wisconsin. 1913.
3. Johannsen, W. The forcing of plants by ether. The American Gardener, 20:251. 1899, and The American Gardener, 21:358–360, 372–373. 1900. Translation by P. Fischer.
4. Morse, J. E. The new rhubarb culture. Orange-Judd Co. New York, 1912.
5. Sayre, C. B. Winter forcing of rhubarb. Ill. Agr. Exp. Sta. Bul. 298. 1927.
6. Stuart, William. Etherization as an aid in forcing rhubarb. Vt. Agr. Exp. Sta. Rpt. 1904, and Vt. Agr. Exp. Sta. Rpt. 1906.
7. ———————. The role of anesthetics and other agents in plant forcing. Vt. Agr. Exp. Sta. Bul. 150. 1910.
8. Vorhees, Jennie A. The use of ether in forcing asparagus, rhubarb and strawberries. N. J. Agr. Exp. Sta. Rpt. 1906.

A Comparison of the Performance of Palmetto and Mary Washington Varieties of Asparagus

By H. A. Jones and W. W. Robbins, *University of California, Davis, Calif.*

THE two leading varieties of asparagus grown in California are Palmetto and Mary Washington. Until recently Palmetto was the chief variety because of its resistance to rust and its productivity. In the East the Mary Washington variety was adopted very readily, but in California the growers were slow to replace the old established varieties like Palmetto and Argenteuil with Mary Washington until it had been tried out experimentally. Most of the large growers put out experimental plantings of Mary Washington as soon as seed was available. They have given it a thorough trial, are satisfied with its performance, and are now planting most of the new acreages to this variety.

Data is now available for four consecutive years showing the performance of Palmetto and Mary Washington varieties grown under similar conditions at University Farm, Davis, California. The crowns were set, in 1924, in separate rows 240 feet long and 7.5 feet apart. Each row has approximately an equal number of staminate and pistillate plants. There are nine rows of each variety and all plots are planted in triplicate. The results are summarized in the following table.

TABLE I—Comparison of Palmetto and Mary Washington Varieties of Asparagus. Averages for 9 Rows of Each Variety

Year	Ave. No. Spears per Plant	Ave. Wt. Spears per Plant in Grams	Ave. Wt. Single Spear in Grams	Ave. No. Stalks per Plant	Ave. Wt. Green Tops per Plant in Pounds	Ave. Yield Spears per Acre
			Palmetto			
1925	5.0	84.1	16.8	7.7	2.6	528.0
1926	13.8	364.4	24.3	7.6	3.0	2285.0
1927	20.7	584.9	28.2	8.6	3.2	3670.0
1928	25.0	701.2	27.9	10.8	3.8	4400.0
			Mary Washington			
1925	4.7	107.5	23.1	5.5	2.3	652.0
1926	11.7	366.3	31.4	6.0	2.7	2295.0
1927	17.4	596.2	34.3	7.5	3.1	3734.0
1928	21.0	728.8	34.6	8.9	3.8	4560.0

Both varieties have yielded about the same. The slightly higher yield in favor of Mary Washington is probably not very significant. The latter variety produces fewer spears per plant but the average size of the spears is larger than those of Palmetto. The Mary Washington also produces fewer stalks per plant after the cutting season than does the Palmetto but the weight of the green tops of the two varieties is about the same.

In 1928, each day's cutting from the above rows of Palmetto and Mary Washington was graded according to size. The five grades used were: "below ⅜ inch in diameter", "⅜ to ½ inch", "½ to ⅝ inch", "⅝ to ¾ inch," and "over ¾ inch." The spears were measured at about 5½ inches from the tip. Table II summarizes the grading results.

TABLE II—TOTAL WEIGHT AND PERCENTAGE OF EACH GRADE. PALMETTO AND MARY WASHINGTON VARIETIES COMPARED (1928)

Variety	Total Yield (Pounds) of All Plots						Ave. Per cent of Total				
	Below 3/8	3/8–1/2	1/2–5/8	5/8–3/4	Over 3/4	Total	Below 3/8	3/8–1/2	1/2–5/8	5/8–3/4	Over 3/4
Palmetto	157.9	616.4	557.2	246.1	22.6	1600	9.9	38.3	34.8	15.4	1.4
Mary Wash'ntn	77.8	440.9	598.0	435.3	107.7	1659	4.7	26.6	35.9	26.3	6.5

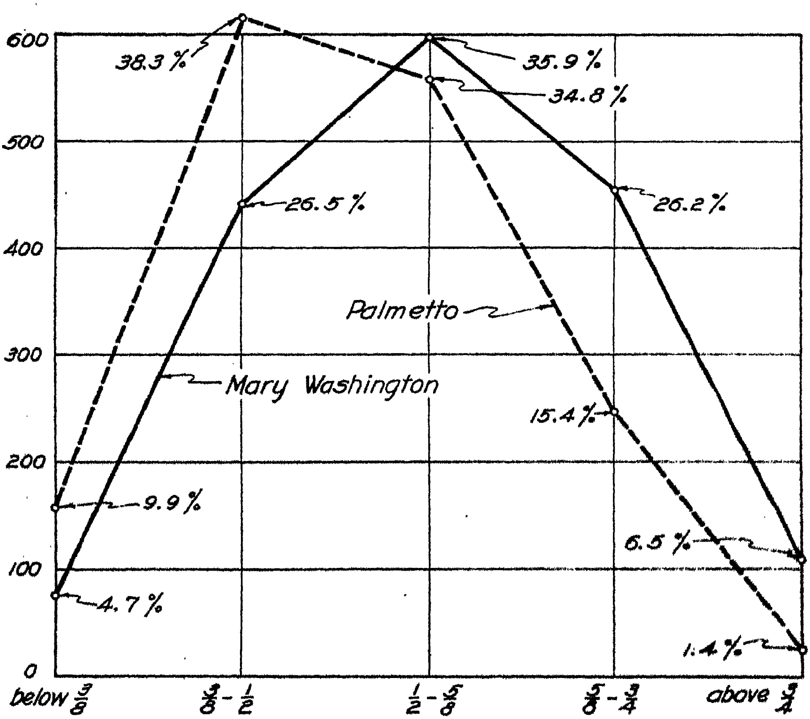


FIG. 1. Comparson of Mary Washington and Palmetto varieties of Asparagus.

It is seen from this table and Fig. 1 that in the two smaller grades Palmetto outyields Mary Washington. As all of the spears below ⅜ inch in diameter are discarded at the cannery, it can be seen that there is more waste because of smaller sizes in the Palmetto variety. In all grades above ½ inch in diameter Mary Washington is superior to Palmetto.

Table III gives the cutting record for the two varieties for five-day periods, during 1928. The figures are based upon the total weight from 9 rows of each variety.

TABLE III—COMPARISON OF PALMETTO AND MARY WASHINGTON VARIETIES AS TO YIELD (POUNDS) OF SPEARS FOR SUCCESSIVE 5-DAY PERIODS, 1928 (ACRE BASIS)

Period	Palmetto	Mary Washington
Feb. 29–Mar. 4	1.5	.8
Mar. 5–Mar. 9	4.0	5.9
Mar. 10–Mar. 14	23.9	31.6
Mar. 15–Mar. 19	103.8	124.6
Mar. 20–Mar. 24	299.3	260.5
Mar. 25–Mar. 29	314.7	290.3
Mar. 30–Apr. 3	447.8	455.2
Apr. 4–Apr. 8	468.9	529.7
Apr. 9–Apr. 13	453.9	477.8
Apr. 14–Apr. 18	414.6	447.7
Apr. 19–Apr. 23	489.3	503.1
Apr. 24–Apr. 28	453.8	447.8
Apr. 29–May 3	476.9	522.6
May 4–May 8	435.6	432.8
May 9–May 13	374.4	387.5
May 14–May 15	115.5	130.9

This table bears out the experiences of growers, that the early cuttings of Mary Washington are slightly heavier than those of Palmetto. The differences shown here, however, are not very significant, commercially.

Experiments in Breaking the Rest Period of Corms and Bulbs

W. E. LOOMIS and M. M. EVANS, *Iowa State College, Ames, Iowa.*

THE senior author recently published (1) the results of researches showing that the rest period of Irish potato tubers may be reduced to one-third of its normal duration by storage under suitable conditions at temperatures around 90°F. We were, therefore, not unprepared to find the starchy corms of gladiolus respond to high temperature treatments for breaking the rest period. The data presented show that there is a very close analogy between Irish potato tubers and gladiolus corms in regard to their response to (1) high storage temperature, (2) high soil temperature, (3) drying, (4) ethylene chlorhydrin treatments, and in the effect of size, varietal differences and cultural treatments on the rest period and growth.

Two series of experiments in breaking the rest period of onion bulbs have shown an unexpected response to high temperature storage and have uncovered a method of breaking the rest period by forced injection of the green bulbs with water which appears promising for use under certain conditions.

Experiments With Gladiolus Corms

A series of preliminary experiments run in the fall and winter of 1927–28 indicated:

1. That vegetative growth in the Halley variety of gladiolus is stimulated by ethylene chlorhydrin treatments, particularly when cut before treating, but that flowering is not greatly ahead of the normal date.

2. That this variety responds to high temperature storage treatments, the best results being obtained with higher temperatures and shorter exposures than were used for Irish potatoes. The blooming date was advanced four weeks by the best treatments and could conceivably have been further hastened by proper treatment of the growing plants.

3. That high soil temperature after planting is an effective method of forcing early varieties of gladiolus.

A more extensive series of experiments now under way in which the Arlon and Marshal Foch varieties are being used, has corroborated all points regarding the vegetative forcing of this plant.

Treatment with ethylene chlorhydrin. Ethylene chlorhydrin treatments have given positive results in forcing the three varieties of gladiolus used. In general the optimum concentrations for dipping, soaking, or gas treatments of whole corms are two or three times those used for cut potato sets. When the corms are halved longitudinally the dosage can be reduced but the plants produced are weak and there is frequently serious loss from rot.

Ethylene chlorhydrin in any concentration used has not proven to be as effective as high temperature storage or as high soil temperature after planting. In the 1928 experiments with Arlon, corms stored one week at 102°F. came up to a full stand two weeks before the best ethylene treatment; the total time in the bench being 24 days for the high temperature storage and 44 days for 5 per cent ethylene dip treatment. No ethylene chlorhydrin treatment of Marshal Foch corms produced better than 50 per cent germination. The best treatment on uncut corms gave 20 per cent germination in 54 days compared with 100 per cent germination in 25 days with the best high temperature storage treatments.

Soil temperature experiments. In 1927 the best germination was obtained by planting Halley corms dipped in 2 per cent ethylene chlorhydrin at 80°F. The germination and growth of untreated corms held at 80°F. was markedly superior to that of treated (2 per cent dip) corms held at 70°F. In the 1928 experiments Arlon previously stored at 102°F. came up to a full stand in 17 days at 75–80°F, but only to a 30 per cent stand in 25 days at 65–70°F. Marshal Foch came up to a 90 per cent stand in 22 days at 75–80°F. and to a 60 per cent stand in 25 days at 65–70°F. One of the difficulties in high temperature storage treatments has been excessive drying. In some cases this has been avoided by packing the corms in wet moss under conditions not unlike those in well aerated soil. No rot has occurred in lots of wet corms held for four weeks at 102°F. and

the wet storage treatments appear particularly promising for this plant. To a considerable extent at least, this treatment can be replaced by high soil temperatures after planting.

Storage experiments. In the 1927 work one lot of Halley corms stored at 102°F. for two weeks was outstanding in both germination and blooming. Tables I and II show that the same is true of the germination of the varieties used in 1928. Ten corms in each lot were planted in a greenhouse bench after receiving the indicated treatment. The best 9 treatments out of 50 used are listed in order of effectiveness.

TABLE I—GERMINATION OF ARLON CORMS WITH DIFFERENT TREATMENTS

Order of Effectiveness	Treatment Before Planting	Date Planted	Per cent Germination	Days to Germinate	Days / Per cent = F
1	Stored 4 wk. 86°F. dry	11/27	100	20	.20
2	Stored 1 wk. 102°F. dry	11/5	100	24	.24
3	Stored 2 wk. 94°F. dry	11/12	100	25	.25
4	Stored 4 wk. 77°F. wet	11/27	100	25	.25
5	Stored 2 wk. 77°F. wet	11/12	100	33	.33
6	Stored 1 wk. 94°F. dry	11/5	100	39	.39
7	2 ml. eth.-chlo. per liter-air 24 hr.	10/29	100	44	.44
8	Dipped 5% eth.-chlor. held 24 hr.	10/29	100	44	.44
9	Check cut in half	10/28	100	45	.45
10	Check—whole (ave. of 3)	10/28	40	55	1.38

The data in Table I suggest that the following storage treatments would have been approximately equal in effectiveness in this experiment.

(a) 1 week at 102°F, (b) 2 weeks at 94°F, (c) 3 weeks at 86°F, and (d) 4 weeks at 77°F.

TABLE II—GERMINATION OF MARSHAL FOCH CORMS WITH DIFFERENT TREATMENTS

Order of Effectiveness	Treatment Before Planting	Date planted	Per cent Germination	Days to Germinate	Days / Per cent = F
1	4 wks. 102°F. wet	11/27	100	25	.25
2	4 wks. 102°F. dry	11/27	60	25	.42
3	2 wks. 102°F. wet	11/12	90	40	.44
4	2 wks. 102°F. dry	11/12	80	40	.50
5	1 wk. 102°F. dry	11/5	50	47	.94
6	Cut—dipped 5% eth.-chlor.	10/29	50	54	1.08
7	Cut—dipped 2% eth.-chlor.	10/29	40	54	1.35
8	4 wks. 77°F. wet	11/27	10	25	2.50
9	Whole—dipped 5% eth.-chlor.	10/29	20	54	2.70
10	Check—whole (ave. 3)	10/28	0	55	∞

All were distinctly better than the check growing at about 65°F. and better than any of the other methods used. The ethylene-chlorhydrin treatments come well down the list. With the exception of the two treatments listed they were no better than the 20 or 30 soaking, cutting, and hot water dip methods which are not of sufficient promise to warrant their continuation.

Up to the present time, storage temperatures below 102°F. have not proven effective in breaking the rest period of the late variety Marshal Foch. Ethylene chlorhydrin treatments in which the corms are dipped into a dilute solution and then stored wet in a tight container for 24 hours, have been ineffective, even on cut corms. The superiority of wet over dry treatments is probably correlated with the rapidity with which this variety loses weight in dry storage. Corms stored dry for 4 weeks at 102°F. lost 24 per cent in weight while those stored wet gained 6 per cent.

Experiments With Onions

The onion experiments have been run in three groups, namely, (1) with a large lot of freshly cured Yellow Bottle Neck sets from Pleasant Valley Iowa; (2) with Yellow Bottle Neck large sets pulled as the tops were breaking over and used at once. (These onions were grown under irrigation at Ames and matured in August); and (3) with large sets and small Yellow Bottle Neck onions from a late crop maturing irregularly under irrigation at Ames. These bulbs lay in the field with some drying weather the first half of October and were held at 60°F. until the experiments were started October 30. The partial completion of the rest period in lots one and three has resulted in characteristic differences in their response and has emphasized the fact that any dormancy treatment must be varied with the depth of the rest period.

The use of ethylene chlorhydrin. Ethylene chlorhydrin has not shown any clear cut instance of abbreviated dormancy in the 30 or more trials that have been made. The slight stimulation shown by some treatments is usually surpassed by lots treated in the same way with tap water. We suggest that the effect of ethylene chlorhydrin in

Table III—The Effect of Ethylene Chlorhydrin on the Growth of Onion Bulbs

Order of Effectiveness	Treatment Given Before Planting	Per cent Germination	Days	Per cent Rot	Ave. Grn. Weight Gms.	Days F[illegible] Per cent
1	Check—cut transversely	84	24	12	2.8	.27
2	Cut—gas ½ ml. per liter—24 hrs.	80	23	20	2.5	.29
3	Cut—soaked 1 hr. in ½% sol.	92	32	8	2.7	.35
4	Cut—gas 2 ml. per L.—24 hrs.	64	23	36	1.8	.36
5	Check—whole (ave. 2)	92	47	6	4.0	.52
6	Whole—gas 2 ml. per L.—24 hrs.	100	55	0	4.3	.55
7	Soaked—5% sol. 5 hrs.	96	55	0	4.7	.57
8	Cut—soaked 2% for 1 hr.	8	12	92	3.5	1.50

breaking the rest period may be connected with the hydrolysis of starch reserves and that this and similar compounds will not be effective in plant organs such as most bulbs, which contain little or no starch reserves. The data given in Table III are typical of the results

obtained on onions with ethylene chlorhydrin. There was no significant stimulation from any of the treatments while serious injury resulted from the heavier doses.

The Effect of Soil Temperature on Onion Dormancy. Our data on soil temperature for the germination of dormant onions are meager, but are, nevertheless, interesting in suggesting an inhibitory effect of high soil temperature accompanied (or caused) by increased rotting.

TABLE IV—SOIL TEMPERATURE AND ONION DORMANCY

Lot and Treatment	Per cent Germination		Germination Factor = F.	
	70°F.	78°F.	70°F.	78°F.
Dry check (lot 1)	100	92	.32	.60
Green check (lot 2)	68	8	.55	6.88
Dry—cut transversely	100	92	.24	.60
Green—cut transversely	100	76	.50	.72

The Effect of Storage Temperature on Onion Dormancy. Some 80 experiments on the effect of storage of onions have given apparently conflicting results in some instances. The best available explanation is that the optimum storage temperature varies with the condition of the bulbs at the time of storage as well as with the duration of the storage treatment. In the first series with Pleasant Valley dry sets of lot 1, 40°F. storage was consistently better than 32°, 55°, and 70°F. At temperatures above 70°F there is a second optimum dropping from 102°F. for a period of one week to 86°F. for four weeks. With fully green onions (lot 2) the 40°F. storage was not appreciably better than the check and three weeks at 102°F. was much better than three weeks at 86°F., as can be seen in Table V. Storage treatments with lot 3 late crop Ames grown sets partially cured, have been intermediate in their response. Two weeks at 102°F. has given good results but so has two weeks at 86°F. and in the four weeks treatments the highest temperature is trailing the moderately high. A certain period of drying seems to be important in breaking the rest period of onions and differences in drying may be found to explain some of the differences in storage temperature response.

TABLE V—EFFECT OF STORAGE CONDITIONS ON THE REST PERIOD OF UNCURED ONION BULBS

Order of Effectiveness	Treatment Given Before Planting	Per cent Germination	Days	Per cent Rot	Ave. Grn. Weight (Gm.)	F = Days / Per cent
1	3 wks. 102°F.	92	25	8	6.6	.26
2	2 wks. 102°F.	84	40	12	6.7	.48
3	1 wk. 102°F.	92	46	0	5.3	.50
4	3 wks. 86°F.	56	31	0	2.9	.55
5	2 wks. 86°F.	72	40	0	2.6	.56
6	4 wks. 86°F.	44	25	0	3.5	.57
7	4 wks. 40°F.	8	25	0	2.0	3.13
8	None—check	4	55	0	3.3	6.88

The Effect of Wounding on Onion Dormancy. Cut tubers of Irish potatoes have a consistently shorter rest period than whole tubers, and the work of Boswell (2) suggests that a greater effect should be

obtained with onions. Boswell's work has been fully corroborated and some 30 trials have shown quicker germination of bulbs cut in such a manner as to allow free access of oxygen to the growing point. Unfortunately the cutting methods which remove a part of the bulb, and removing less than the top half is not fully effective, so weaken the plant and expose the base to rot infection as to make the method undesirable. Splitting the bulbs half way down from the top with two cuts at right angles provides a certain stimulation without loss of food reserves, but is less effective than transverse cutting unless combined with other treatments. The consistently low germination factor for the cut bulbs is accompanied by a low average green weight and a high rot loss. As a rule the ¾ cut treatments came up to a good stand and then most of the plants died from rotting at the base.

Forced Injection of Onion Bulbs With Water. Forced injection of cut or split onion bulbs with tap water has proven to be an exceptionally effective method for forcing freshly harvested bulbs and may be practicable with other bulbs where it is desired to force them immediately for experimental use, identification of variety, inspection for disease and other purposes. We feel that some adaptation of storage treatments will prove to be better for commercial forcing of flowering bulbs because of the heavy losses sometimes obtained by treating partially dormant bulbs with water.

The most convenient procedure which we have used is to clip or split the bulbs, weight them down in tap water at room temperature and exhaust at the vapor pressure of water for one to 20 minutes. The

TABLE VI—EFFECT OF TRANSVERSE AND LONGITUDINAL CUTTING ON THE REST PERIOD OF ONION BULBS

Treatment Given Before Planting	Date Planted	Per cent Germination	Days	$F = \frac{\text{Days}}{\text{Per cent}}$	Ave. Grn. Weight (Grms.)
Check—not cut (lot 1)	8/30	92	47	.51	4.00
Upper ¼ removed	8/30	96	55	.57	3.79
Upper ½ removed	8/30	84	24	.29	2.80
Upper ¾ removed	8/30	48	13	.27	.91
Small grn. ck. (lot 2)	8/30	32	55	1.72	2.62
Upper ½ removed	8/30	68	40	.59	1.05
Med. Grn. Ck	8/30	8	55	6.88	3.25
Upper ½ removed	8/30	96	55	.57	1.58
Large grn. ck	8/30	12	55	4.57	8.83
Upper ½ removed	8/30	84	55	.65	3.33
Check—not cut (lot 3)	10/30	65	53	.82	—
Upper ¼ removed	10/30	95	53	.56	—
Upper ½ removed	10/30	95	25	.26	—
Upper ¾ removed	10/30	60	17	.28	—
Split longitudinally	10/30	95	34	.36	—

vacuum is then quickly released and water forced in to replace the air exhausted from the intercellular spaces of the bulb scales. Moderately dry bulbs will take up 20 to 30 per cent of their weight of water. This method is not recommended for partly dormant bulbs that have been stored at relatively high temperatures. Some of the results

obtained on bulbs from lot 3 are given in Table VII. Vacuum treatments on cut or split bulbs gave very quick and complete germination. Treatments on whole bulbs were no better than the check although considerable quantities of water were taken up. Treatments on bulbs previously stored for two weeks at 86°F. resulted in the rotting of all treated bulbs. The same result has been obtained with tulip and narcissus bulbs.

TABLE VII—THE EFFECT OF FORCED INJECTION WITH WATER ON THE REST PERIOD OF ONION BULBS

Order of Effectiveness	Treatment Given Before Planting	Date Planted	Per cent Germination	Days	F = Days / Per cent
1	Cut ½—vacuum 15 min., H_2O	10/30	100	11	.11
2	Cut ½—vacuum 3 min., ½% eth. chlor.	10/30	95	13	.13
3	Split—vacuum 3 min. H_2O	10/30	100	15	.15
4	Cut ½—vacuum 3 min., H_2O	10/30	95	19	.20
5	Cut ½—soaked in H_2O, 1 hr.	10/30	95	23	.24
6	Cut ½—not treated	10/30	95	25	.26
7	Whole—vac. 15 min. H_2O	10/30	65	53	.83
8	Whole—not treated	10/30	65	53	.83
9	2 weeks 86°F.+vac. 5; H_2O	11/15	rotted	40	8

SUMMARY

The foundation of a method for forcing gladiolus corms which combines high storage and high soil temperatures is outlined. Gladiolus corms have given responses in all the treatments used which are analogous to the responses of Irish potato tubers.

Fully matured but still green onion bulbs have had their rest period greatly shortened by dry storage at 95 to 105°F. for two to three weeks. Bulbs cured in the field will probably give best results at the lower temperature. The method of transverse cutting which has been recommended by Boswell is surpassed by longitudinal splitting of the tops of the bulbs so as to admit air without removing any of the food reserve.

During the early part of the rest period, onion and probably other similar bulbs can be forced at once by splitting combined with forced injection of tap water. The method is especially adapted to use in identification of variety or inspection for bulb borne diseases.

It is suggested that vegetative organs containing stored starch will have their rest periods shortened by ethylene, ethylene chlorhydrin, ether, and similar compounds, while organs such as bulbs containing little or no starch will not show the same response. This theory has held in the work that we have done with tulip, narcissus, and onion bulbs; gladiolus and crocus corms; Irish potato tubers; and apple twigs.

LITERATRUE CITED

1. LOOMIS, W. E. Temperature and other factors affecting the rest period of Irish potato tubers. Plant Physiol., 2:297–302. 1927.
2. BOSWELL, V. R. Influence of the time of maturity of onions upon the rest period, dormancy, and responses to various stimuli designed to break the rest period. Proc. Am. Soc. Hort. Sci., 20:225–233. 1923.

The Relation Between Rate of Planting and Yield in Garden Beans

By M. C. Gillis, *University of Illinois, Urbana, Illinois*

THE proper spacing of garden bean seed in the row to obtain the best yield is naturally determined by the size of plant and habit of growth, and by the fertility and moisture content of the soil. The average rate of planting used by commercial growers, according to Hardenburg (1), is one bushel of seed per acre, a practice based on general experience rather than on any extensive experimental results. The experimental evidence available indicates that larger yields might be expected by the use of higher rates of planting.

In 1894 Halsted (2), working with the Golden Wax variety, in comparing distances of 3, 6, 12, and 24 inches between plants in rows 20 inches apart, found that the thickest rate gave the highest yield. However, there was more disease on the closely spaced plants. The following year in another experiment in which the spacings between plants were 4½, 9, and 18 inches, he obtained similar results. In 1897 Jordan (3), comparing a green pod and a wax pod variety planted at various rates, found that plants grown at the rate of six plants per foot of row produced the largest percentage of the crop at the first picking. The highest yield, however, was obtained where the plants were spaced 10 to the foot.

The data presented in this paper, extending over a period of four years, are the results of experiments carried on at the Cornell Agricultural Experiment Station, and, subsequently, at the Illinois Agricultural Experiment Station. The Cornell experiments were begun in 1922 and continued thru 1923 with the helpful suggestions of Professor E. V. Hardenburg and Professor Paul Work. The work was later resumed at the Illinois Experiment Station in 1927.

Materials and Methods

Three bush bean varieties of the green pod type, Red Valentine, Burpee's Stringless Green Pod, and Stringless Refugee, were used throughout the experiments. These varieties were selected because of the differences in size and type of plant. The plant of the Red Valentine variety is rather small and erect, and has a compact type of growth. Burpee's Stringless Green Pod produces a plant that is less compact, medium in size, and carries more foliage. The Refugee variety produces a heavy, dense growth of foliage; the plants have a spreading habit of growth and cover the ground between the rows more nearly completely than the other two varieties. Refugee proved to be about ten days later than Red Valentine and Burpee's Stringless Green Pod.

In 1922 each of the three varieties was planted at rates of 2, 3, and 6 plants per foot of row. For reasons which will be mentioned later, the range of planting rates was extended in 1923 to rates of 3, 6, 9, and 12 plants per foot. The numbers of pounds of seed equivalent to these rates of planting were determined from samples of each

variety. The arrangement of the plots was such that the maximum and minimum rates were not adjacent to each other, thus eliminating as much as possible the effect of competition between rows.

The plots, except in 1922, were single rows twenty feet in length, spaced three feet apart. The entire series was replicated seven times. In 1922 the plots were forty feet in length and were replicated three times. The yield per acre for each variety and each rate of planting was calculated from the average yield of eight plots (four plots for 1922) distributed over the experimental area. The seeds were planted thicker than the planting rate to be tested, and the plots thinned to the required stand when the plants were about three inches high. Therefore, where the term "rate of planting" is used it means thickness of stand after the plots were thinned. The beans were harvested at three or four day intervals as circumstances permitted.

The varieties, plan of planting, and method of procedure used in the Illinois experiments were the same as those used in the 1923 Cornell experiment. Seed was obtained from the same source throughout. Student's method was used to calculate the probability that a given difference in yield between two rates of planting is biometrically significant.

Season and Soil Variations

The amount of rainfall was extremely variable. Heavy rains preceded planting in 1922 and the season continued wet throughout the growing period, conditions which were favorable for good germination, luxuriant plant growth, and a long bearing period. The 1923 season was extremely dry, delaying germination several days. The yields were relatively small and the quality poor. In 1927 the rainfall in Illinois was abundant during most of the growing season, while in 1928 it was more nearly normal and more favorable for pod production as indicated by the yields. Hot weather, which may occur during the period of pod production and affect the yield, particularly of the later varieties, was a factor in 1928.

The soil type at Cornell varies from Volusia silt loam to gravel and is too heavy and low in fertility to be considered a good bean soil. The brown silt loam soil at Urbana is higher in fertility and more uniform as to type.

Experimental Results

The yields from the 1922 and 1923 crops, expressed in pounds of green beans per acre, are given in Table I.

In 1922, when the planting rates were 2, 3, and 6 plants per foot, each increase in the rate gave a corresponding increase in the yield of each variety. Although the "odds" indicating the biometrical significance of the yield differences between successive planting rates are in most cases low, the yields obtained show a significant trend, and indicate that "rate of planting" was an important factor in determining the yield. Larger yields might have been obtained

TABLE I—SHOWING THE INFLUENCE OF VARIOUS RATES OF PLANTING ON THE YIELDS OF THREE VARIETIES OF GARDEN BEANS IN THE CORNELL EXPERIMENTS (1922 AND 1923)

Variety	Rate of Planting		1922					1923				
	Plants per ft. of Row	Equivalent Lbs. of Seed per Acre*	Lbs. of Green Beans per Acre	Yield Differences Between Successive Planting Rates in the Series	Student's Odds	Yield Differences Between the Two and Six Rates	Student's Odds	Lbs. of Green Beans per Acre	Yield Differences Between Successive Planting Rates in the Series	Student's Odds	Yield Differences Between Nonsuccessive Planting Rates in the Series	Student's Odds
Red Valentine	2	25	7396					—				
	3	37	8728	+1332	39:1	+2171	30:1	1731			(3 & 9 rates) +447	24:1
	6	75	9567	+ 839	12:1			1906	+175	3:1	(3 & 12 rates) +107	4:1
	9	112	—					2178	+272	9:1	(6 & 12 rates) — 68	2:1
	12	150	—					1838	—340	52:1		
Burpee's Stringless Green Pod	2	30	7305					—				
	3	45	8717	+1412	18:1	+2047	64:1	1754			(3 & 9 rates) +299	4999:1
	6	90	9352	+ 635	7:1			2008	+254	6:1	(3 & 12 rates) — 34	1:1
	9	135	—					2053	+ 45	2:1	(6 & 12 rates) —288	6:1
	12	180	—					1720	—333	73:1		
Refugee	2	20	8831					—				
	3	30	9687	+ 856	7:1	+1366	25:1	1839			(3 & 9 rates) + 58	2:1
	6	60	10197	+ 510	29:1			1974	+135	2:1	(3 & 12 rates) —262	3:1
	9	90	—					1897	— 87	7:1	(6 & 12 rates) —397	9:1
	12	120	—					1577	—320	12:1		

*On the basis of 100% germination.

from higher rates of planting. The low "odds" have probably resulted from using too few replications. The increase in yield was larger, in every case, between the *two* and *three rates* than between the *three* and *six rates*. In other words, there was a tendency for the yield difference to decrease as the optimum rate of planting was approached. The difference between the yields from the 3- and 6-per-foot rates varied inversely with the size of the variety. This might have been expected on the basis that the large variety will stand less crowding than the small variety. The differences in yield between the *two* and *six rates* are biometrically significant in the case of the Red Valentine and Burpee's Stringless Green Pod varieties, and nearly so in the case of Refugee, if "odds" of not less than 30:1 are accepted to denote reliability.

It was evident from the 1922 yields that the optimum rate was not exceeded in spacing the plants 6 to the foot. The plan of planting was therefore revised in 1923. Since a rate of 2 plants per foot was obviously too thin for all three varieties, it was omitted, and the range was extended to include rates of 9 and 12 plants per foot.

The lack of rainfall in 1923 reduced the yields to about 20 per cent of the 1922 yields and gave rise to considerable variation among the eight replicates of each planting rate. The odds, therefore, showing the significance of the differences in yield are low in most cases.

The general trend of the 1923 yields was consistent with that of the 1922 data. The yields tended to increase as the planting rate was increased to a certain limit. The largest yields were obtained from Red Valentine and Burpee's Stringless Green Pod at the 9-per-foot rate, and from Refugee at the *six rate*. Beyond these rates the yields showed a decided decrease. Two points are significant in the 1923 data, namely, (1) the total gain in yield between the minimum and optimum planting rates became less as the size of variety increased, and (2) with the exception of Burpee's Stringless Green Pod at the *six rate*, the number of pounds of green beans per acre obtained from the *three* and *six rates* varied in direct relation with the size of variety, while the yields from the *nine* and *twelve rates* decreased considerably in the same direction. These facts indicate that where Red Valentine, a small variety, was used, a rate of planting of less than 9 plants per foot had a tendency to be an important factor in reducing the yield. On the other hand where the large variety, Refugee, was planted, crowding the plants tended to be more effective than thin planting in decreasing the yields.

The yields obtained from the Illinois experiments are given in Table II. Unlike the Cornell results, all varieties except Burpee's Stringless Green Pod in 1927 gave the best yields where the plants were spaced 12 to the foot. Even Refugee showed no decrease in yield under the more crowded conditions. The averages of the two years show that the largest yields for all varieties were obtained where the thickest rate was used. This deviation from the 1923 results may be accounted for by a difference in soil fertility and more favorable conditions of rainfall.

TABLE II—SHOWING THE INFLUENCE OF VARIOUS RATES OF PLANTING ON THE YIELDS OF THREE VARIETIES OF GARDEN BEANS IN THE ILLINOIS EXPERIMENTS (1927 AND 1928)

Variety	Rate of Planting		1927			1928			Average		
	Plants per ft. of Row	Equivalent Lbs. of Seed per Acre*	Lbs. of Green Beans per Acre	Yield Differences Between Successive Planting Rates in the Series	Student's Odds	Lbs. of Green Beans per Acre	Yield Differences Between Successive Planting Rates in the Series	Student's Odds	Lbs. of Green Beans per Acre	Yield Differences Between Successive Planting Rates in the Series	Student's Odds
Red Valentine	3	37	4515			7929			6222		
				+1395	>9999:1		+ 983	97:1		+1189	>9999:1
	6	75	5910			8912			7411		
				+ 590	77:1		+1076	315:1		+ 833	5999:1
	9	112	6500			9988			8244		
				+ 306	6:1		+ 182	2:1		+ 244	6:1
	12	150	6806			10170			8488		
Burpee's Stringless Green Pod	3	45	4067			7271			5669		
				+1310	4999:1		+ 382	11:1		+ 846	1656:1
	6	90	5377			7653			6515		
				+ 374	26:1		+ 55	1:1		+ 215	8:1
	9	135	5751			7708			6730		
				— 153	3:1		+ 505	19:1		+ 176	5:1
	12	180	5598			8213			6906		
Refugee	3	30	2014			5434			3724		
				+1650	1999:1		+1884	>9999:1		+1767	>9999:1
	6	60	3664			7318			5491		
				+1571	>9999:1		+ 475	9:1		+1023	4999:1
	9	90	5235			7793			6514		
				+ 369	6:1		+ 108	2:1		+ 238	5:1
	12	120	5604			7901			6752		

*On the basis of 100% germination.

An analysis of the data by Student's method, however, shows that in some cases the yield increases are not very significant. None of the varieties had a significant increase in yield when the planting rate was higher than 9 plants per foot. The odds are only 5 to 1 that the differences in yield obtained in the two year average between the rates of 9 and 12 plants per foot were not due to chance alone.

All varieties in 1927 and Red Valentine in 1928 showed a substantial increase in yield where the plants were spaced 9 to the foot as compared with the 6-per-foot rate, and the latter in turn showed an increase over the *three rate*. In 1928 when the average rainfall was less and the yields larger than in 1927, the increases shown by Burpee's Stringless Green Pod at the 6- and 9-per-foot rates and that of Refugee at the *nine rate* were not very conclusive, the differences being relatively small and the individual plot yields more variable.

CONCLUSIONS

From the data obtained it is apparent that size and type of plant, amount of rainfall, and soil fertility greatly influenced the yields of the three varieties and determined the best planting rate.

In the dry season of 1923 on poorly adapted soil a rate of 9 plants per foot where Red Valentine and Burpee's Stringless Green Pod were used, and the rate of 6 per foot in the case of Refugee gave the largest yields. Under the conditions named above these are the optimum rates for the three varieties. On the more fertile brown silt loam of Illinois and with favorable moisture conditions, each of the varieties gave the most significant increase in yield at the 9-per-foot rate. Apparently Refugee may be planted more thickly where moisture and soil fertility are not limiting factors, and the 9-per-foot spacing can be used for all three varieties without danger of overcrowding. However, small increases in yield may be expected in some seasons when the rate is extended to 12 plants per foot. With favorable conditions for growth it may be profitable to plant at the thicker rate, depending upon the relation between cost of seed and the price obtained for green beans. The 9-per-foot rate agrees with the optimum rate of 10 plants per foot as determined by Jordan. The closest spacing used by Halsted was 4 plants per foot which gave his highest yield. Had he used thicker plantings with disease free material, even better yields might have been obtained.

Where soil and moisture conditions were unfavorable as in 1923, size of plant and type of growth exerted a marked influence upon the yields. In the case of a large, spreading variety like Refugee, under such conditions overcrowding becomes an important factor in decreasing the yield. The optimum planting rate for this variety, as indicated above, is 6 plants per foot, while where somewhat smaller varieties, such as Red Valentine and Burpee's Stringless Green Pod, are used the best yields may be obtained at a 9-per-foot rate. Even in 1922, when the rainfall was abundant, Refugee as compared with the other two varieties gave relatively smaller increases

in yield as the rate of planting became thicker. The size of plant and habit of growth also influence the yield where the rate of planting is below the optimum; the decrease in yield is greatest in the case of the small variety and diminishes as the size of plant increases. The reaction of size of plant and habit of growth on yield was not confirmed under the conditions of the Illinois experiments due to the fact that at the highest rate of planting in these experiments competition had not yet become operative to the extent of reducing the yield.

Literature Cited

1. Hardenburg, E. V. Bean culture. New York. 1927.
2. Halsted, B. D. Report of the botanist. New Jersey Ag. Exp. Sta. Report. 290–292. 1895.
3. Jordan, A. T. Thickness of Planting. New Jersey Agr. Exp. Sta. Report. 166–167. 1898.

Relation of Some Physical and Chemical Changes to Potato Dormancy

By Ora Smith, *University of California, Davis, California.*

NUMEROUS methods of breaking the dormant period in potatoes have been reported and are quite generally known but the mechanism of growth releasal has not yet been explained.

It is the object of these experiments to determine the respiratory rates of several varieties of potatoes: first, at various stages of maturity; second, while they are passing through the dormant state at various storage temperatures; and third, after they have been subjected to dormancy shortening practices and to correlate, if possible, the respiration rate with the abbreviation of the dormant period. These experiments are preliminary to further work concerning permeability of the skin to gases and conductivity of the tissue as correlated with the dormant period.

Appleman (1914) showed that the abbreviation of the rest period is correlated with greater oxygen absorption and respiration. In an effort to determine whether the lengths of the rest periods of various varieties are correlated with their rates of respiration, four varieties, White Rose, Irish Cobbler, Bliss Triumph and Early Ohio of the 1928 spring crop were stored at 25°C. Averages of three sets of determinations show that White Rose had the shortest rest period and highest rate of respiration followed by Early Ohio. with Bliss Triumph and Irish Cobbler having the longest rest period and lowest rates of respiration, therefore showing a direct relation between rate of respiration of each of the four varieties and the lengths of their rest periods when stored at 25°C. The product of respiration rate and length of rest period for each of the four varieties is almost equal.

To determine the relation between rates of respiration of the above four varieties stored at various temperatures and the length of their rest periods, tubers of each variety were stored at temperatures of

4°, 25°, 30° and 35°C. All varieties acted similarly, the respiration rate being highest at 35°C. and decreasing in order through 30°, 25° to 4°C, with the lowest rate. However, under the conditions of these experiments those tubers stored at 25°C. had the shortest rest period, with 30°, 35° and 4°C. following in order. No direct correlation exists in these experiments between rates of respiration at various temperatures and length of the rest period.

Appleman (1914) shows the abbreviation of the rest period to be correlated with greater oxygen absorption but indicates that it is improbable that sprouting was brought about by the greater energy release resulting from the increased respiration. The results obtained in these experiments, of which the following tables are typical, appear to bear this out. Different lots were treated with ethylene chlorhydrin, ethylene dichloride and stored moist and untreated, all at 25°C.

With White Rose the storage in moist sphagnum moss at 25°C. and the treatments with ethylene chlorhydrin and ethylene dichloride stored at 25°C. resulted in an equal abbreviation of the dormant period, reducing it to 12 days. A comparison of the data of Tables I and II, shows the large differences in the rates of respiration between moist stored tubers and those treated with ethylene chlorhydrin and ethylene dichloride indicating further that sprouting is not brought about by greater energy releasal. Although the Irish Cobbler moist stored lots had a longer dormant period than the chemical treatments, this is probably partly due to the delay in treatment of the former. The rates of respiration of the chemical treated tubers are so much higher, however, that the same conclusions are derived as with White Rose.

Appleman (1914) found that the suberization of the skin or of cut surfaces greatly reduced permeability to water and to gases. He states that the rapidity and degree of suberization is greatly influenced by moisture; dry conditions favor the process while moisture retards it, and any process facilitating greater oxygen absorption appears to abbreviate the dormant period. Rosa (1928) showed that when tubers were stored at 4° and 30°C. the dry and moist tubers sprouted approximately at the same rate, but at 22° the moist samples sprouted much more rapidly than the dry lots. Rosa suggests that moist storage at 4°C. does little to abbreviate dormancy, due to the limitation of the low temperatures and at 30°C. the effect of the moisture is not generally additive because the high temperature itself brings about the most rapid termination of the dormant condition that is possible. Loomis (1927), however, found that at moderate storage temperatures the dry potatoes gave the best germination, while at high temperatures those stored in moist moss showed least injury and made the best growth. He suggests that the beneficial effect of the moss apparently lay in the conservation of moisture rather than in the reduction of suberization. Loomis concludes that storage in damp moss has had no direct effect upon the rest period.

Results from work now being conducted by the writer seem to indicate that when tubers are stored moist at 25°C. the rest period is

TABLE I—RATES OF RESPIRATION OF TUBERS STORED DRY AND MOIST AT 25°C.
Mgms. CO_2 per kgm. hour

Treatment	Irish Cobbler (Dug. July 2)							White Rose (Dug July 12)					
Date	7/4	7/9	7/13	7/19	7/24	7/31	8/13	7/15	7/19	7/24	7/31	8/13	8/26
Stored dry..........	7.5	6.3	5.2	5.5	5.6	5.2	6.0*	10.5	7.4	7.1	—	7.3*	7.2
Stored moist........	—	—	9.7	6.7	7.7*	10.0	10.1	—	11.1	11.4*	14.1	13.9	10.1

*All tubers sprouted. Stored moist July 9.

TABLE II—RATES OF RESPIRATION OF TUBERS TREATED WITH ETHYLENE CHLORHYDRIN, ETHYLENE DICHLORIDE AND UNTREATED STORED AT 25°C.
Mgms. CO_2 per kgm. hour

Treatment	Irish Cobbler (Dug July 2), Treated July 2–3								White Rose (Dug July 12), Treated July 13–14					
Date	7/4	7/9	7/16	7/21	7/26	7/31	8/13	8/24	7/15	7/20	7/25	7/30	8/10	8/24
Untreated....	7.5	6.3	5.5	5.0	5.3	5.2*	6.0	6.5	10.5	8.3	7.6	—	7.4*	7.2
Ethylene chlorhydrin.	65.6	25.3	16.2*	11.4	10.6	9.5	10.7	8.4	56.9	14.8	12.4*	11.0	10.2	8.9
Ethylene dichloride....	39.3	53.9	26.8*	21.2	16.9	13.4	17.7	10.4	69.4	25.4	17.9*	12.9	11.1	10.9

*All tubers sprouted.

appreciably abbreviated and the skin becomes more permeable to gases.

Since respiration furnishes the energy for growth, it appeared of interest to follow the rates of respiration in tubers as they approach maturity and to compare varieties having a short and a long dormant period. Lots of immature White Rose and Irish Cobbler tubers were dug at 10- or 11-day intervals beginning May 21 and ending July 2 for mature Irish Cobbler and July 12 for mature White Rose. They were stored at 25°C. The results are shown in Table III.

TABLE III—RESPIRATION OF IRISH COBBLER AND WHITE ROSE POTATOES DURING THE GROWING PERIOD AND IN STORAGE AT 25°C.

Variety	Date Dug	Mgms. CO_2 per kgm. hour—14 Day Intervals						
Irish Cobbler	May 21	31.0	9.4	4.9	4.1	5.2	4.8*	6.7
	May 31	19.4	6.2	5.3	4.1	4.7	5.4*	—
	June 11	11.8	5.1	4.6	4.6	5.5*	—	—
	June 21	15.1	5.9	4.3	5.4*	—	—	—
	July 2	12.2	5.5	5.2*	6.0	—	—	—
White Rose	May 21	37.9	12.3	8.2	6.2	6.2	4.5*	6.8
	May 31	27.3	10.8	6.3	5.0	4.2*	4.9	—
	June 11	22.0	8.1	5.7	4.1	5.4*	—	—
	June 21	18.9	8.1	5.8	6.4*	—	—	—
	July 2	13.0	7.2	5.1*	4.6	—	—	—
	July 12	10.5	7.6	7.4	7.2*	—	—	—

*All tubers sprouted.

These data show a greater respiratory activity in the earlier dug, more immature tubers with a progressive decrease in activity as maturity advances. They also show a gradual and regular decrease during storage at 25°C. until all diggings are approximately equal. At every digging White Rose shows greater respiratory activity than Irish Cobbler; the former also has the shorter dormant period although this is not strikingly shown in these data because of the long intervals between observations. The respiration rate as a rule increases slightly with the resumption of growth. At the end of the rest period, when growth is resumed, respiration rates in all the lots regardless of date of digging are approximately the same. Appleman and Miller (1926) suggest that the higher rate of respiration in immature potatoes for a period after digging appears to be due to the fact that the skins are more permeable to gases. The writer is now engaged in studies concerning the permeability of the skins of tubers as the potatoes mature throughout the growing season.

Rosa (1923) suggested that one effect of stimulants on the tuber may be a change in cell permeability of the interior cells and Loomis (1927) also suggests that dormancy may be related to cytoplasmic structure and that the rest period may be broken by some changes in the cytoplasm whereby the permeability of the cell is increased and enzymes are liberated. In an attempt to find any such changes in the tissue of potato tubers the writer has used two methods, namely, the rate of absorption of water by disks of potato tissue by the method given in Stiles (1924), and the measurement of the electrical

conductivity of the tuber tissue with a modification of the method suggested by Osterhout. The electrodes are similar to those used and described by Latimer (1926) and Overholser (1927). Although the writer realizes the shortcomings and questionable merits of the above methods as measurement of permeability it is believed that some interesting results may be obtained therefrom.

Literature Cited

1. Appleman, C. O. Study of rest period in potato tubers. Md. Agr. Exp. Sta. Bul. 183. 181–226. 1914.
2. Appleman, C. O., and Miller, E. V. A chemical and physiological study of maturity in potatoes. Jour. Agr. Res., 33:569–577. 1926.
3. Latimer, L. P. Physiological changes occurring in pear fruits during growth and ripening as determined by electrical conductivity. Univ. of Calif. (unpublished thesis) 1926.
4. Loomis, W. E. Temperature and other factors affecting the rest period of potato tubers. Plant Physiol., 2:287–302. 1927.
5. Overholser, E. L. Some studies upon the ripening and removal of astringency in Japanese persimmons. Proc. Amer. Soc. Hort. Sci., 256–266. 1927.
6. Rosa, J. T. Abbreviation of the dormant period in potato tubers. Proc. Amer. Soc. Hort. Sci., 180–187. 1923.
7. Rosa, J. T. Relation of tuber maturity and of storage factors to potato dormancy. Hilgardia, 3:99–124. 1928.
8. Stiles, Walter. Permeability. New Phytol. Reprint No. 13. London. 1924.

Some Effects of Greensprouting Seed Potatoes

By E. V. HARDENBURG, *Cornell University, Ithaca, N. Y.*

AMONG the practices commonly recommended for the preparation of seed potatoes for planting is greensprouting. For years, greensprouting has been commonly practiced in west European countries where it is claimed that it results universally in earlier maturity and usually in increased yields. In this country, the practice is by no means general but appears to be on the increase. The results of experiments testing its merits are various and conflicting and point the need for further careful investigation.

In March 1928, a greensprouting experiment with both Rural and Green Mountain potatoes was conducted under both greenhouse and field conditions. Altho the greenhouse phase was subject to the limitations of relatively few plants in each treatment, it was possible to insure uniform and constant soil conditions and to observe growth rate by actual measurements. Uniform size tubers of disease-free seed were selected, one-half of which were cut transversely to equal weight, 2-ounce pieces, placed cut surface down into flats of moist sand, and set in a warm greenhouse at 70° F. to greensprout. The other half of the tubers were stored in a cool cellar at 45 to 50° F. until both lots were potted on April 3rd after a period of 20 days. Equal weight of soil was placed in each pot and the seed-pieces were covered to a depth of 4 inches. Only seed-end pieces were used, these being placed apical end up in 10-inch clay pots. The untreated lots of both varieties were practically dormant at potting time. Sixteen plants of each treatment and of each variety were observed from potting time until harvest on June 18th, a period of 76 days. Superphosphate (16 per cent) was applied at the rate of one ton to the acre and mixed with the surface 4 inches of soil. All cultures were watered twice a week to constant weight, a soil moisture content of about 20 per cent (wet basis) being maintained. The plants were grown at a temperature range of 55 to 65° F.

The effect of greening on earliness of comeup is shown in Table I. It is obvious that early growth was distinctly enhanced by green-

TABLE I—EFFECT OF GREENSPROUTING ON DATE OF COMEUP (1928)

Variety and Treatment (Ave. of 16 Plants Each)	Per cent of Plants Up		
	April 17	April 20	April 26
Green Mountain			
Greened	87.5	100.0	100.0
Ungreened	00.0	00.0	100.0
Rural			
Greened	50.0	75.0	100.0
Ungreened	68.8	100.0	100.0

sprouting in the Green Mountain variety, while no significant difference resulted in the Rurals. In fact, complete comeup in the ungreened Rurals occurred several days ahead of the greened lots.

This difference in performance between the Green Mountain and the Rural types must be explained not on the basis of inherent varietal differences but on the difference in degree of dormancy of the seed at the beginning of the greening period. At this time no sprout growth whatever was evident in the Green Mountain seed while sprouts had made about one-eighth inch growth on practically all of the Rural tubers.

A measure of vigor may be expressed as rate of growth over a definite period of time. The effect of greensprouting on rate of growth is shown in Table II. The well-known tendency of the Green Mountain variety to produce more stems per plant than the Rural is borne out in this study. Greening appears to have reduced somewhat the number of stems in the Green Mountain variety but the difference is probably not significant. Stem number was not affected in the Rurals. A greater maximum height of plant was maintained in the plants from greened seed of both varieties throughout the experiment in spite of the fact that the ungreened seed of the Rural variety produced a somewhat earlier comeup. However, a study of the data in Table II shows that maximum height of plant is not correlated with total stem length. Altho maximum plant height in both varieties was greater from the greensprouted seed, total stem length in the plants from the ungreened seed gradually caught up with and finally exceeded that from the greened seed. In other words, rate of increase in stem length per day was greater from the greened seed during the first 39 days of growth after potting. Thereafter the growth rate as determined on May 31 and June 18, was distinctly higher in the plants from the ungreened seed. These results may well explain why some experiments have shown results favorable to greening where early maturity was involved and less favorable results when a longer growing season made it possible for plants from ungreened seed to mature normally.

The plants were harvested on June 18, seventy-six days after potting. The plants were not mature but the flower buds had dehisced and the lower leaves had begun to yellow. The object of harvesting before maturity was to recover as large a proportion as possible of the tubers, roots and stolons by washing them from the soil. The results are summarized in Table III. Very small differences in green weight of tops of both varieties between greened and ungreened seed are shown, and these differences are neither consistent nor large enough to be considered significant. On the contrary, the effect of greening on tuber set and yield is rather marked in both varieties. It is common opinion that greensprouted seed will develop a higher tuber-set than seed not treated because of a shortening of the internodes and a corresponding increase in node number on the underground portion of the stem. The data in Table III clearly indicate a higher tuber number both per plant and per stem in each variety. Greensprouted seed also gave a significantly higher yield and a higher percentage of tubers weighing over one ounce than that not greened. These increases may be ascribed to the more rapid early growth of the plants from the greened seed. Whether

TABLE II—EFFECT OF GREENSPROUTING ON RATE OF GROWTH IN POTATOES (1928)

Variety and Treatment (Ave. of 16 Plants Each)	No. of Stems per Plant	Maximum Height of Plant (Inches)			Total Stem Length per Plant (Inches)			Ave. Increase in Stem Length per Day Beginning April 3 (Inches)		
		May 12	May 31	June 18	May 12	May 31	June 18	May 12	May 31	June 18
Green Mt.										
Greened.....	4.19	14.4	17.2	17.6	51.5	61.8	63.3	1.3	.5	.09
Ungreened...	4.50	11.1	14.6	15.8	44.8	59.3	65.5	1.2	.8	.34
Rural										
Greened.....	1.88	18.9	27.7	28.2	31.3	46.9	47.6	.8	.8	.04
Ungreened...	1.88	17.5	26.7	27.1	29.7	46.7	48.7	.7	.9	.11

TABLE III—EFFECT OF GREENSPROUTING ON YIELD OF TOPS, TUBERS, STOLONS AND ROOTS OF POTATOES (1928)

Variety and Treatment (Ave. of 16 Plants Each)	Green Weight of Top (Ozs.)	Number of Tubers		Green Wt. of Tubers per Plant (Ozs.)	Tubers Weighing Over 1 Ounce (Per cent)	No. of Stolons per Plant	Green Wt. of Stolons per Plant (Ozs.)	Green Wt. of Roots per Plant (Ozs.)
		Per Plant	Per Stem					
Green Mountain								
Greened..........	3.38±.074	23.75±1.278	5.67	4.54±.143	88.5	32.50±1.319	.069	.628±.272
Ungreened........	3.29±.076	17.69±0.976	3.93	3.91±.096	71.4	22.19±0.985	.088	.538±.307
Rural								
Greened..........	4.13±.059	13.56±0.544	7.21	3.83±.142	84.1	14.94±0.604	.138	.669±.024
Ungreened........	4.26±.071	11.94±0.765	6.35	2.99±.161	69.9	9.88±0.774	.125	.706±.034

this increased yield and size of tubers would be maintained until maturity is to be determined by a field test. The number of stolons per plant was significantly higher in the greened seed in both varieties and, therefore, correlates closely with tuber-set. Green weights of neither stolons nor roots show any significant effect of the greening factor.

Green Mountain and Rural seed of the same strains used in the greenhouse experiment were used in testing the effects of greensprouting under field conditions. Duplicate lots of uniform tubers were spread on a large table for greening on May 1st, the corresponding lots being stored in good cellar storage until planting time. The seed was cut into pieces averaging 1¾ ounces in weight on May 30th. The greensprouted seed after exposure for 30 days had developed sprouts at the apical end averaging about one-half inch long. The cellar-stored seed bore sprouts averaging slightly longer but these were removed in the handling incident to cutting. Fifteen rows of 25 hills each of both greened and ungreened seed of both varieties were planted alternately on June 4th.

No significant difference in time of comeup of the greened and ungreened seed could be observed in either variety. Thorough Bordo spraying thruout the season kept the plots free from blight and tipburn. Inspection for virus disease on August 24th gave a record of 3 per cent leaf roll in the Rurals and 1 per cent mosaic and .3 per cent leaf roll in the Mountains. No differences in degree of maturity between the greened and ungreened lots were evident just before the plots were harvested on October 10th. Data on number of stems per plant, number of tubers per stem and yield are given in Table IV.

A study of potato literature in reference to greensprouting reveals almost no actual data on the factor of stand of plants. Yet statements are usually made that the practice results in a better and a more uniform stand as a result of elimination of the diseased, dormant, and weak-sprouting tubers. This would seem to be a logical result. The data in Table IV show a stand of plants better by 6 to 8 per cent from the ungreened seed of both varieties. In 9 out of 15 paired-row comparisons in both varieties, the stand from ungreened seed exceeded that from greened seed. That from the greened seed exceeded the ungreened only twice in the Green Mountain and three times in the Rural variety. Such differences would appear to be significant. Seedbed conditions and rhizoctonia injury must be eliminated as a factor in explanation since the seed was treated and the seedbed well prepared. Further work is necessary to determine the true effect of greening on stand of plants.

Further evidence that greensprouting tends to reduce stem number per plant is shown in Table IV. Also the greening process resulted in a higher tuber-set per stem corresponding to, tho less marked than, the data obtained in the greenhouse experiment. Here as in the greenhouse results, the percentage of U. S. No. 1 size tubers was consistently greater from the greened seed. The difference was

TABLE IV—EFFECT OF GREENSPROUTING ON STAND, TUBER-SET, AND YIELD IN POTATOES (1928)

Variety and Treatment (Ave. of (15)25-Hill Row Plots Each)	Stand of Plants (Per cent)	Number of Stems per Plant[1]	No. of Tubers per Stem[1]	Yield per Acre in Bushels[2]		U. S. No. 1 Yield per Acre (Per cent)
				Total	U. S. No. 1	
Green Mountain						
Greened	92.0	3.20	2.08	275.2	244.9	89.0
Ungreened	97.9	3.56	2.06	273.3	228.1	83.5
Rural						
Greened	86.1	2.34	2.36	253.3	234.3	92.5
Ungreened	93.6	2.90	2.28	285.5	256.7	89.9

[1]Weighted average.
[2]Unweighted average.

sufficient in the Green Mountain variety to show 16.8 bushels per acre of U. S. No. 1 in favor of the greened seed. Since unweighted averages were used in arriving at these yields, the poorer stands from the greened seed considerably reduced the yields from these lots. This may help to explain but certainly does not negate the fact that in the Rural variety the U. S. No. 1 yield from the ungreened seed exceeded that from the greened seed by 22.4 bushels. The experiment is to be continued.

Conclusions

Certain definite effects of greensprouting appear in these studies' namely, (1) a more rapid vigorous growth rate in the early growth period from greened seed which is later overtaken by plants from ungreened seed; (2) a reduction in number of stems per plant; (3) an increase in number of stolons per plant; (4) an increase in number of tubers per stem; and (5) an increase in percentage of U. S. No. 1 yield per acre. Among the factors which appear to be little or not at all affected by greening are relative top growth, stolon weight and root weight. The effect on stand and total yield per acre constitutes a major problem on which further carefully controlled work should be done. The relation of greening to these factors is probably conditioned by the character of the sprouts on both the greened and the ungreened tubers at time of planting.

A Parthenocarpic Hybrid Derived from a Cross Between an English Forcing Cucumber and the Arlington White Spine

By RICHARD WELLINGTON and LESLIE R. HAWTHORN,
Experiment Station, Geneva, N. Y.

IT is commonly known that the English forcing cucumbers develop fruit freely without the application of pollen and that bees or artificial pollination are necessary to secure a satisfactory crop of the American forcing types, such as the White Spine. There is some question as to whether cucumber varieties can be divided into strictly parthenocarpic and non-parthenocarpic types, considering the results obtained by Canadian co-workers. W. J. Strong of Vineland in a letter of November 16, 1928 writes that every one of the 33 varieties tested in a greenhouse with screened ventilators possessed this parthenocarpic character to a greater or less extent. He further states, "the long Green English Forcing type as a rule form the most fruits, while such varieties as Princess and Early Russian form very few. There seems to be considerable variation in the individuals of a variety in this regard and it would seem that environment also would have considerable influence on the number of fruits formed without pollination." Professor A. H. McLennan of Guelph states in a recent letter, that in 1910 he crossed an English variety, Sutton's Every Day, with Fiske White Spine and in 1911 crossed this hybrid with Princess, seed of which was obtained in Germany. From this latter cross two parthenocarpic types were selected, one with white and the other with black spines. From seed of this cross the Vineland Station obtained the variety Hescrow, which sets fruit perfectly without fertilization. T. Becker in "Handbuch des Gemüsebaues" 1924, page 621, says, "Parthenocarpy is present in most of the old English forcing varieties, further in Weigelts Bester von allen, Wettbewerb, etc. Non-parthenocarpic are Blaus Konkurrent, Becks Namenlose, etc. In early forcing the latter sorts must also be artificially pollinated." Parthenocarpy tests conducted at the Geneva Station confirm in part the results obtained in Canada. Such being the case, the terminology of parthenocarpy in the cucumber has to be applied with reservations, but from the practical grower's standpoint such fine distinctions do not have to be drawn, for the production of one or two often misshapen fruits is equivalent to a failure.

The main advantages of a parthenocarpic type, providing the fruit is neither misshapen nor abnormal, is that the set is not dependent upon weather conditions, insects, or hand-pollination. Further, since the seeds do not develop, there should be less drain on the plants and a consequent increased production.

In 1907 the senior writer tested two plants of a hybrid between the White Spine and the English forcing Telegraph for parthenocarpy by covering the stigmas prior to the normal opening of the flowers with carbolized vaseline. Some of the treated flowers dropped, while others produced seedless fruits which tapered at the distal end. The

remainder of the hybrid plants set similar fruits, and as no bees were present owing to inclement weather, it was assumed that the cross was parthenocarpic. The flesh of the unfertilized fruits was slightly tougher and poorer flavored than that of the fertilized fruits, and later in the season after a hot humid period developed a hollow center.

In 1912, a more extensive study of parthenocarpy was undertaken. The objects in view were to determine: first, how prevalent parthenocarpy was in cucumbers; second, whether it segregated like visible characters; and third, whether a commercial parthenocarpic type that was intermediate between the long English type and the short stubby American type could be produced. Pistillate flowers of a number of varieties were bagged prior to opening. Two fruits were obtained from a plant of Japanese Climbing which resembled the English forcing type, one from Early Russian, one from Thorburn Everbearing, and many from the English forcing varieties, namely, Richard Invincible, Lockie Perfection, and Telegraph. No parthenocarpic fruit was obtained, however, from Early Green Cluster, Fordhook White Spine, Fiske White Spine, and F_1 plants of crosses between White Spine and Telegraph and White Spine and Richard Invincible. The results of this test indicated that the parthenocarpic character behaved as a recessive to the non-parthenocarpic character.

In 1913, one parthenocarpic fruit was obtained from an F_1 plant of White Spine by Richard Invincible and one from three F_1 plants of Fiske White Spine by Early Russian, so the dominance can not be called complete. In a test of six plants of a back cross (Fiske White Spine x Richard Invincible) x Richard Invincible, only one parthenocarpic fruit was obtained. On the other hand, of the F_2 generation of Fiske White Spine by Richard Invincible six plants gave one fruit each; one, two fruits; 12, no fruits; and three, no test. Undoubtedly this number of fruits would have been greatly increased if bagging had been continued throughout the season. The fruits of the F_2 generation were classed in most parts as intermediates, although three plants were predominantly English.

Unfortunately these crosses were not tested further, as the senior writer moved to Minnesota. The project, however, was continued but new material had to be secured. The remainder of the report is based upon work started at Minnesota. The writers wish to give due credit to the Minnesota Agricultural Experiment Station for permitting the senior writer to take a portion of the seed with him when he left in 1920, to Professor F. A. Krantz of Minnesota for submitting a copy of a portion of the original notes for publication, and to the Maryland Agricultural Experiment Station for growing a generation of plants.

Only one cross will be considered in the remainder of the paper and this one was selected because it is the parent of the parthenocarpic type noted later. This cross was produced in 1916 by crossing the Arlington White Spine with Rochford Market, the latter being an English forcing variety. Eleven F_1 seedlings were grown in 1917 and their fruits were intermediate in length, constricted at the neck like Rochford Market, and generally warty like White Spine. As far as

can be recalled none of the F_1 plants nor the White Spine were parthenocarpic, but Rochford Market developed seedless fruit. Plant 1 of the first generation was selfed, and in 1918 nine F_2 plants were grown. Only plant 7 of the F_2 generation was parthenocarpic. All, however, were selfed for further trial. The fruit of plant 1 in this F_2 generation appeared to be of commercial promise and was described as being 10½ inches long, not necked, tapering gradually at stem and abruptly at the distal end, slightly russeted, and similar to Abundance in appearance.

Two years later (1920) five F_3 plants derived from plant 1 of the F_2 selection were grown at the Maryland Agricultural Experiment Station. R. W. Axt, a student assistant, tested these plants for parthenocarpy and found that all of them set fruit without being pollinated. The fruits of these plants varied in shape, some approaching the White Spine type and others the Rochford Market. Like theie parent, the neck of the Rochford Market and the wartiness of White Spine were lacking. Unfortunately seed was not procured from these types.

Seven years later (1927) seed of the F_2 generation that had been stored in envelopes for nine years was turned over to the junior author, who has been carrying on the project for the past two years. The remainder of this report deals with the results of his work.

The progeny of nine selfed F_2 plants involved in the test of 1927 gave 39 F_3 plants. The germination of the seed was, of course, in a number of cases poor, and hence only three plants were obtained from plant 1, the selection tested at Maryland. As soon as the plants were large enough to bear fruit female flowers were bagged in as large numbers as possible in order to test for parthenocarpy. It soon became apparent that the progeny of certain F_2 plants were useless commercially. They produced male flowers in great numbers, to the almost complete exclusion in some cases of female flowers. They also failed to give satisfactory results parthenocarpically.

Other progenies showed greater possibilities thru one or more favorable characteristics such as, high production of female flowers, parthenocarpic tendencies, and high production of edible fruit. Among these were three plants obtained from plant 1, whose progeny had been previously tested at Maryland. These three plants attracted particular attention as they were vigorous, produced female flowers in a normal abundance, reacted favorably parthenocarpically, and set attractive high quality fruits. A typical parthenocarpic fruit cut from plant 1 of this group was 10½ inches long and 2⅜ inches at its greatest diameter about 3 inches from the stem. Altho the fruit tapered gradually in both directions, good thickness was maintained thruout, and there was no restriction of the neck. The surface was smooth except for a few scattered white spines. Color was a medium to dark green, the general color being a little lighter than that so much in demand at the present time. The seed cavity was 1 inch wide surrounded by a layer of white crisp flesh averaging ¾ of an inch in thickness. All of these plants were selfed as well as a number of others, which for reasons mentioned above looked promising.

About 50 plants were grown in 1928. Five plants represented the F_3 generation of the most promising selection mentioned above. The remainder, with the exception of a few other F_3 plants of another selection (which has now been discarded) consisted of the F_4 generation.

When the plants had attained a good growth they were tested for parthenocarpy by covering all the unopened female flowers with a little wad of absorbent cotton. This was held in place by an elastic band. This procedure had several advantages. It was easier and hence quicker to perform than the more clumsy bagging method; the development of the fruit could be watched without any further labor; the fruit developed under more normal conditions; there was less chance of injury to young tissues of the flower and undeveloped fruit.

All the plants (F_3 and F_4) which came from plant 1 of F_2 responded even better than in 1927. Many fruits which had not been tested for parthenocarpy developed too, and because of their shape and the absence of bees in the greenhouse early in the season, were assumed to have developed without pollination. This indicated that these particular plants were capable of at least fairly high yields in spite of their being the fourth generation of selfing. The fruits were quite uniform in shape and size and were so similar to the description already given of an F_3 fruit that no further description is necessary. Occasional fruits showed a slight restriction of the neck. The persistent parthenocarpic character in the plants selected together with the other desirable characters found in the fruit indicate that the cucumber is more or less fixed.

Parthenocarpy in the strict sense of the word may not be completely dominant over non-parthenocarpy in the cucumber, but parthenocarpy as applied to a commercial set of fruit is evidently dominant over non-setting or the production of very few fruits. The parthenocarpic type selected from the cross Arlington White Spine by Rochford Market promises to have commercial value for those markets which prefer a cucumber of intermediate length, providing the lack of an intense green skin color is not a serious handicap. For breeding purposes this cucumber should have merit for its important characters are evidently homozygous and if crossed with a parthenocarpic type, all the progeny should be capable of developing without pollination.

An Interesting Effect of Green Sprouting Upon the Value of Seed Pieces From the Apical and Basal Ends of Potatoes

By H. D. Brown, *Purdue University, Lafayette, Ind.*

THE apical ends of Rural seed potato tubers, grown at Lafayette in 1928, yielded over five times as much as corresponding equal sized pieces taken from the basal ends of the same tubers. (Table I.) The apical ends from another lot of tubers selected from the same shipment of certified potatoes yielded but slightly less than twice as much as the basal sets from the same tubers. This difference in yield, between selected tubers from the same lot, is due in a large measure to the localized presence of sprouts on the green sprouted tubers which enabled the sprouted pieces to produce plants while the unsprouted seed rotted in the soil. These sprouted seed pieces were apparently better able to withstand the unfavorable growth conditions existing at the time the sets were planted, than were the unsprouted sets. Thus the yields which result from seed pieces taken from different regions of the potato tubers may depend to a large extent upon the presence or absence of greened sprouts, and as will be shown later, the presence of these sprouts on the different portions of the tubers cannot always be conveniently regulated by green sprouting.

TABLE I—Stand and Yield Data of Green Sprouted, Apically Dominant and Non-Apically Dominant, Rural Potatoes Lafayette, Indiana, 1928

Treatment		Stand Per cent	Yield	
			Pounds per Plot*	Per cent No. 1
Apically dominant seed	Apical end	25.5	169	87
	Basal end	5.1	33	82
	Average	15.3	101	86
Seed not apically dominant	Apical end	22.1	137	85
	Basal end	11.4	71	79
	Average	16.7	104	83

*1/12 of an acre.

The tests were designed to compare the value of apically and non-apically dominant Rural seed potatoes. A comparison of the stand, yield, and degree of sprouting obtained from sets taken from different portions of the same tuber are much more striking than a comparison of the yields from the apical and non-apically dominant potatoes. Certified Rural potatoes of supposedly high yielding qualities were secured in May from Albert Miller and Company of Chicago, Illinois. They were treated with corrosive sublimate solution before they had started to sprout, and were then placed in diffused light in a well lighted room and allowed to green sprout. As soon as the sprouts were well started, all the tubers which sprouted only at the apical end were separated from those that had sprouted at the middle and basal portions of the tubers. At planting time (June 10) the seed

pieces (2 ounces in weight) from the apical ends were planted separately from the seed pieces, (of the same weight) taken from the basal ends of the same tubers. The seed pieces were dropped with an Iron Age potato planter so that they were 18 inches apart in rows 36 inches apart. Beginning a few days after the seed was planted the soil was kept rather wet for several weeks because of frequent rains. Seed planted at Lafayette and elsewhere in the State during this period rotted badly in the fields. A similar situation prevailed throughout the state in 1920. The potatoes were dug on October 9 after the vines had been killed by frost on September 23.

The comparative value of apical and basal potato sets is a much mooted question. Some investigators present data to prove that the apical end is more productive than the basal end. Others present equally convincing data to support the superior productivity of the basal portion of the seed tubers. Stuart, Edmundson, Lombard, and Dewey (4) review the literature on this subject and conclude that, "It is therefore doubtful whether there is any real difference in their value for seed purposes." At the same time they call attention to the tests conducted by Myers (3) which indicate that the apical sets yield more than the basal sets. Stuart *et al* (4) conclude from their own data that, "as the weight of the set increases there is a greater response from the apical than from the basal set."

The data presented in Table I of this paper show that under the conditions of this experiment, i.e., when seed pieces rot in the soil, the sprouted apical ends of apically dominant tubers have a far greater value than sets from the basal ends of the same potatoes. The data show in addition that the apical ends of the non-apically dominant potatoes have a greater value than the basal regions of the same tubers. This difference is perhaps due to the greater vigor of the apical sprouts as compared to the basal sprouts. Obviously the presence of greened sprouts is a most important factor in the production of good stands and high yields during seasons when the seed pieces rot in the soil. It is also obvious that the value of apical and basal sprouts during such seasons will vary with the degree of apical dominance of the seed used. This may explain in part the difference in results secured during the past by different investigators. Appleman (1) and Brown and Hoffman (2) have shown that the degree of apical dominance exhibited by various lots of potatoes varies to a large degree.

There is likewise an equally great division of opinion relative to the value of greened and ungreened seed. Most investigations show a decided advantage for green sprouting although Rosa (5) concluded that the practice is not profitable. Stuart *et al* (4) concluded, as a result of three year's tests, that, "The differences are too small, however, to support the claim of superiority for green-sprouted seed."

The results of the tests herein reported indicate that green sprouting is of special importance during a season when the seed pieces rot in the soil, provided each seed piece has a sprout attached. Thus potatoes which under ordinary conditions would produce higher yields, due to the association of apical dominance and high yielding

capacities, might under conditions similar to those reported in this paper produce lower yields than potatoes from the same lot but not apically dominant. The difference in yield in this case would be due to the production of a better stand from the larger number of sprouts on the tubers not apically dominant. This actually happened in the Lafayette tests although the yield differences in this case are not significant. It is significant in this connection to note that the apical sets from the apically dominant potatoes yielded better than the apical sets from the non-apically dominant tubers.

No conclusions can, however, be drawn from these tests relative to the seed value of apically dominant Rural potato tubers. It is evident from the differences here noted that the effects of green sprouting may be augmented or be nullified by conditions associated with or quite apart from the green sprouting factor. Here, again, lies a possible explanation for the difference in results obtained by different investigators.

The tests indicate that the presence of green sprouts on potato sets is an advantage during years when the seed pieces rot in the soil. Since apically dominant potatoes produce green sprouts only on the apical end, the apical ends of green sprouted tubers are of far greater value than the basal ends of the same potatoes. Since the growth of sprouts cannot be regulated in green sprouting it is evident that the basal sets from non-apically dominant tubers are of more value, during periods when the sets rot in the soil, than the basal ends of apically dominant tubers. This may be true in spite of the fact that the apically dominant potatoes under ordinary conditions have (1), (2), outyielded the non-apically dominant potatoes.

Literature Cited

1. Appleman, C. O. Potato sprouts as an index of seed value. Md. Agr. Exp. Sta. Bul. 265. 1924.
2. Brown, H. D., and Hoffman, I. C. The potato seed situation in Indiana. Proc. Am. Soc. for Hort. Sci., 41–45. 1927.
3. Myers, C. H. Improving the potato crop by selection. N. Y. State Col. Agr. Cornell Reading Courses, 3:229–248. (Plant Breeding Ser. No. 3.) 1924.
4. Stuart, William, Edmundson, W. C., Lombard, P. M., and Dewey, G. W. Source, character, and treatment of potato sets. U. S. D. A. Tech. Bul. 5. 1927.
5. Rosa, T. J., Jr. Seed studies with irish potatoes. Mo. Agr. Exp. Sta. Bul. 191, 32. 1922.

A New Late-Seeding, Mosaic-Resistant Hybrid Spinach

By H. H. ZIMMERLY, *Truck Experiment Station, Norfolk, Va.*

The Occurrence and Prevention of Calyx Injury in Washed Apples

By HENRY HARTMAN, *Oregon Agricultural College, Corvallis, Ore.*

Investigations of Soil Moisture and Apple Root Distribution at Olney, Illinois

By W. A. RUTH, C. EDWARD BAKER, and J. S. POTTER, *University of Illinois, Urbana, Ill.*

Immediate and Residual Effects of Spraying Materials on Yield of Fruits in the Apple

By W. C. DUTTON, *Michigan State College, East Lansing, Mich.*

Some Carbohydrate and Nitrogen Constituents of Alternate Bearing Sugar Prunes Associated With Fruitbud Formation

By L. D. DAVIS, *University of California, Davis, Calif.*

A Suggested Classification of the Genus *Brassica*

By O. H. Pearson, *University of California, Davis, California.*

A species is a group of individuals of common descent with certain constant characters in common which are represented in the nucleus of each cell by constant and characteristic sets of chromosomes. (Hurst, 1927.)

The genus *Brassica* is distinctly polymorphic. Schulz (1919) describes 33 species. The chromosome number of some of the cultivated forms has been determined and is given in Table I. Schulz places white mustard and charlock in the genus *Sinapis*. The genus *Brassica*, therefore, is composed of plants containing 8, 9, 10, or 18

TABLE I—Chromosome Numbers in Different Species of Brassica

Species	Plants Used for Verifying Chromosome Counts	n	2n	Citation
B. oleracea L.	Sprouting broccoli	—	18	Karpechenko 1922
		9	—	Shimotomai 1924
		9	—	Gallastigui 1926
		—	18	Netroufal 1927
B. montana		—	18	Netroufal 1927
B. campestris L.	Wild form	10	—	Shimotomai 1924
B. rapa L.	Red Top White Globe Turnip	—	20	Karpechenko 1922
		10	—	Gallastigui 1926
		10	—	Shimotomai 1924
B. pekinensis Rupr.	Wong Bok Chinese cabbage	10	—	Shimotomai 1924
B. chinensis L.	Bak Toy mustard	—	20	Karpechenko 1922
		10	—	Shimotomai 1924
B. japonica Sieb.		10	—	Shimotomai 1924
B. alba (L.) Boiss	White English mustard	—	24	Karpechenko 1922
		16	32	Laibach 1907
B. napus L.	Dwarf Essex rape		36	Karpechenko 1922
B. juncea Czern.	Gai Toy, Takana—Chinese green mustard	—	36	Karpechenko 1922
		18	—	Shimotomai 1924
B. cernua Forbes & Hemsl.		18	—	Shimotomai 1924
B. nigra Koch	Wild form	—	16	Karpechenko 1922
B. arvensis L. B.S.P.	Wild form	—	18	Karpechenko 1922

pairs of chromosomes. Karpechenko (1922) found that crosses between species having the same number of chromosomes are easily made, but much more difficult to make when the species are of different chromosome numbers. Sinskaia (1927), in a more extensive series of tests, finds that the F_1 and F_2 of crosses between parents of like chromosome numbers are highly fertile, with the exception of crosses between members of *B. napus* and *B. juncea*. He likewise finds that crosses between plants of different chromosome numbers are not easy to make. It is easier to cross plants with 10 and 18 pairs of chromosomes when the 18-chromosome parent bears the seed,

as in the case of rutabaga with 18 pairs crossed with turnip with 10 pairs. His results support and are supported by the work of Sutton (1908), Ragionieri (1920), and Nelson (1927). Two years of attempts in making similar crosses at University Farm, Davis, California, agree with these findings. Under conditions of open pollination every silique set seeds when the parents had the same number of chromosomes.

The results of the 1928 crossing operations are given in Table II. The figure in the upper left hand corner of each square represents the number of flowers crossed; that in the upper right corner, the per cent of siliques setting; and the central figure, the average number of seeds per silique. All the turnip plants died at mid bloom from soft rot, a fact which explains the poor results obtained when they were used as the seed parent. From these results it appears that the varieties having 10 pairs of chromosomes intercross easily, giving a good set of seeds. Varieties having 18 pairs of chromosomes also intercross readily, although it appears that when *napus* varieties are crossed with those of *juncea*, better results are secured when the *juncea* plants bear the seed. These data are too limited to be conclusive but tend to agree with the results of Nelson, Sinskaia, and others. However, in crosses involving individuals of 10 and 18 pairs of chromosomes, the results substantiate those of Nelson (1927) and others, in that a better set was secured when the 18-pair parent bore the seed.

The white mustard, *Sinapis alba*, was incompatible in any combination with the others. Likewise numerous attempts to cross cabbage, *B. oleracea*, black mustard, *B. nigra*, and charlock, *S. arvensis* with any of the plants listed in Table II were unsuccessful. This is in agreement with the results of Sinskaia and Nelson, but Lund and Kjaerskou (1886) successfully crossed cauliflower and summer rape, and Ragionieri (1920) crossed Chinese cabbage, *B. chinensis*, with a fodder variety of *B. oleracea*, and with cauliflower.

The results of Sutton, Ragionieri, Karpechenko, Nelson, and Sinskaia, and the data here presented serve to point to the conclusion that the varieties having 10 pairs of chromosomes are closely related; that the varieties having 18 pairs of chromosomes are closely related also, but apparently can be further divided into two groups, one of which, the *napus* or rape group, is more closely related to the 10 chromosome group than is the other, or *juncea* group. The morphology of the plants agrees with this idea. The rape and the turnip have the same sort of lobed leaves, the same type of cordate-clasping cauline leaves, and identical flower color. However, the open flowers of the turnip are above the tip of the raceme; the sepals are wide spreading, and hair "pustules" on the rosette leaves are very common. On the other hand, the open flowers of the rape are at least an inch below the tip of the raceme; the sepals are nearly erect; and the lower leaves, while usually with epidermal hairs, do not have the characteristic "pustules" of the turnip.

All the members of the 10-chromosome group resemble one another in the characters mentioned above. They vary in vegetative

TABLE 11—RESULTS OF 1928 CROSSING OPERATIONS

Group ♂	Sub-species	Variety name	No. chr.	Chinese Cabbage Wong-bok	Turnip Red-top White Globe	Chinese Lettuce Santosai	Indian oil Mustard Sarson	Pak-choi Bak-toy	Rape Dwarf Essex	Rutabaga Tankard	Oriental Mustard Gai-toy	Oriental Mustard Takana	Oriental Mustard Chinese grn.	Mustard Southern Curled	Mustard White Eng
♀ Group				BRASSICA CAMPESTRIS					BRASSICA NAPUS		BRASSICA JUNCEA				SINAPIS ALBA
♀ Sub-species				pekinensis	rapa	pekinensis	campestris	chinensis	napo-brassica						
				10″	10″	10″	10″	10″	18″	18″	18″	18″	18″	18″	12″
BRASSICA CAMPESTRIS	pekinensis	Chinese cabbage Wong-bok	10″	—		12 42% —		Lost	21 95% 8	20 95% 7	20 100% 0		Lost	10 6% 0.3	
	rapa	Turnip Red-top white globe	10″	21 62% 0.3	—			Lost	37 81% 11	33 73% 8					
	pekinensis	Chinese lettuce Santosai	10″	16 100% 8		—		Lost	12 33% 8				24 50% 1		
	campestris	Indian oil mustard Sarson	10″	9 100% 16			—	13 77% 7	12 100% 7				15 53% 1		
	chinensis	Pak-choi Bak-toy	10″	12 100% 12		7 100% 12	3 33% 11	—			7 72% 1	11 100% 0.7	18 39% 0	9 67% 0	Failed
BRASSICA NAPUS	napo-brassica	Rape Dwarf Essex	18″	Lost	Lost	8 100% 6	8 100% 0		—	12 92% 20		12 100% 18	21 90% 7	12 67% 8	Failed
		Rutabaga Tankard	18″	25 96% 0	Lost					—					
BRASSICA JUNCEA		Oriental mustard Gai-toy	18″	Failed			11 91% 0.1	Lost			—		27 44% —	15 53% 9	Failed
		Oriental mustard Takana	18″						11 91% 1			—	4 100% 5		
		Oriental mustard Chinese gr.	18″	5 80% 0		Failed	11 100% 0	Failed	26 92% 0.3		16 56% 4	10 100% 11	—	12 100% 0.1	Failed
		Mustard Southern Curled	18″	Failed			10 30% 0		10 70% 3		6 100% 8	11 100% —	5 100% 6	—	
SINAPIS ALBA		Mustard White English	12″					Failed	Failed						—

characters only, and by selection new forms can easily be derived from our present types. They intercross freely, give fertile F_1 and F_2 populations, and although no detailed cytological investigation has been made of these crosses, the preliminary study indicates that pairing is normal and that no irregularities occur at the reduction division. The chromosomes must, therefore, be very similar in genic content. Lund and Kjaerskou (1886) have traced the evolution of the turnip from the wild turnip, *B. campestris*, of Europe. The other varieties are Asiatic in origin; they may possibly have been derived from *B. campestris* plants selected in another direction to meet the different needs of the people of India and China. The fact that after centuries of separation the chromosomes are still sufficiently alike to pair and behave as those of a normal individual argues strongly for a common origin. For that reason, then, these species should be reduced to subspecies rank. There is no doubt that they intercross spontaneously; their natural hybrids are only too common.

The oriental mustards, *B. juncea*, although they have 18 pairs of chromosomes, are sufficiently different from the rapes, *B. napus*, in crossing relations and in gross morphology to be entitled to separate specific rank. The cauline leaves are sessile or petioled as contrasted to the cordate-clasping cauline leaves of the rape. The petals are also a different shade of yellow, and the sepals of the open flower are more reflexed. The cytology of the cross has not been studied, but Sinskaia (1927) found that the F_1 was rather sterile, which would indicate a high percentage of irregularities at the reduction division, or possibly the regular formation of non-viable zygotes.

Black mustard, with eight pairs of chromosomes, has given negative results in all attempts to cross it with members of the genus *Brassica*. Schulz recognizes its distant relationship and places it in the section *Melanosinapis* of *Brassica*. Its morphology would seem to place it somewhere near *S. arvensis* but its chromosome number is eight pairs, while that of *S. arvensis* is nine. A form with extra chromosomes sometimes arises from a species by plus aberation, so that *S. arvensis* might have been derived from *B. nigra* in which case the latter would be the more primitive; Jaretsky (1928) has suggested that the basal set of chromosomes in *Brassicaceae* (9 pairs) might have been derived from a *Coringa*-like form with 7 pairs by plus aberations.

Coringa-like form	7 pairs
B. nigra	8 pairs
S. arvensis	9 pairs

If this is the case, *B. nigra* and *S. arvensis* are very closely related. They resemble each other in type, color and texture of leaf, in having petiolate cauline leaves, and in appearance of the open flower. In these characters they differ from members of *Brassica*. Black mustard then would seem to belong with *Sinapis arvensis* and it is suggested that it be known as *Sinapis nigra*. According to this idea we have a new arrangement of the genus *Brassica*, based on chromosome number and crossing relations as shown in Table III. ✓

Schulz gives the last five varieties under *B. oleracea* specific rank. However, many years ago Lund and Kjaerskou (1886) studied in the botanical gardens of Europe the varieties *balearica*, *insularis* and *cretica*, and from their morphology and the fact that they hybridized easily with forms of *B. oleracea* giving fertile progeny, came to the conclusion that they were but forms of *B. oleracea.* Netroufal (1927) has counted the chromosomes in var. *montana* and describes it as a very closely related form of *B. oleracea.* Sinskaia (1927) similarly described var. *alboglabra.*

Schulz mentions the turnip as a variety of *B. campestris.* He describes var. *chinensis* under *B. napus*, but from crossing relations determined by Sinskaia, it is obviously one of the *campestris* group even were its chromosome number unknown. The chromosomes of *B. campestris* var *nipposinica* have not been counted as far as I know, but Sinskaia finds that it behaves in species and variety crosses exactly the same as does Chinese cabbage, var. *pekinensis.*

TABLE III—SUGGESTED CLASSIFICATION OF THE CULTIVATED SPECIES OF *Brassica*

Brassica oleracea L.	(n = 9)	
var *sylvestris* D. C.		wild cabbage
ramosa (D. C.) Celefeld		tree kale
acephala D. C.		leaf kale
bullata D. C.		
sub var *sabauda* L.		savoy cabbage
gemmifera D. C.		Brussels sprouts
capitata L.		head cabbage
botrytis L.		cauliflower
gonglyodes L.		kohlrabi
montana P.		
alboglabra Bailey		
balearica Pers.		
insularis Moris		
cretica Lam		
Brassica campestris L.	(n = 10)	
var *rapa* Babington		turnip
pekinensis Rupr.		Chinese cabbage
chinensis L.		Chinese cabbage
nipposinica Bailey		
Brassica napus L.	(n = 18)	
var *typica* Pospichal		rape
napobrassica (L.) Reichb.		rutabaga
Brassica juncea (L.) Czern.	(n = 18)	
var *cernua* (Thumb) Forbes & Hemsl.		
crispifolia Bailey		southern curled mustard
Sinapis nigra (Koch)	(n = 8)	black mustard
Sinapis arvensis L.	(n = 9)	charlock
Sinapis alba L.	(= 12)	white mustard

Within the *B. juncea* group, there are several horticultural varieties. They vary from the leaf characters of Southern Curled to those of Takana, or Gai-Toy. Those grown at Davis, namely, Takana, Gai-Toy, Southern Curled, and Chinese Green mustard, have 18 pairs of chromosomes and intercross readily.

In conclusion, therefore, from genetic and cytological findings, we can divide the cultivated Brassicas into but four species; the varieties

within each species have the same chromosome number, and intercross readily giving a fertile F_1. Crosses between varieties of different species are possible in some cases but are always more difficult to make, reciprocal crosses are not made with the same ease, and the F_1 is either entirely sterile or but partially fertile.

Literature Cited

1. Gallastigui, C. Número de cromosomas en algunas especies del género Brassica. Bol. R. Soc. Espan. Hist. Nat. 26 (3) 185–191, fig. 4. Citation from Biol. Abst., 1:8508. 1927.
2. Hurst, C. C. The conception of a species. Science (n. s.) 65:271–273. 1927.
3. Jaretsky, R. Untersuchungen über Chromosomen und Phylogenie bei einigen Cruciferen. Jahrb. Wiss. Bot., 68:1–45. 1928.
4. Karpechenko, G. D. The number of chromosomes and the genetic correlation of cultivated Cruciferae. Bull. Appl. Bot. and Pl. Breeding, 13: 3–14. 1922.
5. Laibach, F. Zur Frage nach der Individualitat der Chromosomen in Pflanzenreiche. Bot. Centralblatt, 22:191–209. 1907.
6. Lund, S. og Kjaerskou, H. Morphologisk-anatomisk Berkrevelse af B. oleracea, B. campestris, og B. napus. Botanisk Tidsskrift, 15:1–151, pl. 1–16 (Fr. summary pp. 1–40). 1886.
7. Nelson, A. Fertility in the genus Brassica. Jour. Genetics, 18:108–135, pl. 1. 1927.
8. Netroufal, F. Zytologische Studien über die Kulturrassen von *Brassica oleracea*. Osterreickische Bot. Zeitschr., 76:101–113, pl. 2. 1927.
9. Ragionieri, A. Brassica crosses. Gardner's Chronicle, 68:60 (July 31). 1920.
10. Schulz, O. E. Cruciferae-Brassiceae. Das Pflanzenreiche, IV: (105). A. Engler, W. Englemann, Leipzig. 1919.
11. Shimotomai, N. A karyological study of Brassica. I. Bot. Mag. Tokyo, 39:122–127, fig. 12. 1924.
12. Sinskaia, E. N. Geno-systematical investigations of cultivated Brassicas. Bull. Appl. Bot. and Pl. Breeding, 17:141–166. 1927.
13. Sutton, A. W. Brassica crosses. Bull. 1:1–10, pl. 1–12. Publ. by Sutton and Sons, Reading, England. 1908.

Inbreeding the Table Queen (Des Moines) Squash

By E. S. HABER, *Iowa State College, Ames, Iowa.*

THE Table Queen squash is the most important market variety in Iowa. On the larger markets, such as Des Moines, Sioux City, and Davenport, it has supplanted the larger types of squash, as the Hubbard and Marblehead. Because of the impurity of the commercial seed, which contains 10 to 25 percent off types and perhaps a higher percentage of poor quality specimens, the Iowa Agricultural Experiment Station in 1922 undertook the problem of producing a strain of this variety which would be superior to the commercial ones.

The Table Queen is called a squash, but in reality it is a true pumpkin. Oastetter and Erwin (3) in their classification of pumpkins and squashes have placed this variety in the Fordhook group of *Cucurbita pepo*. It crosses readily with other varieties of *Cucurbita pepo*. Doubtlessly this has been the cause for many off-type specimens in the variety. It was thought that by inbreeding pure lines would be isolated which would be uniform in color, shape, size, and quality.

Darwin (6) working with naturally cross-fertilized species concluded that in general cross-fertilization was beneficial and self-fertilization often injurious. Following his work on orchids he stated that "nature abhors perpetual self-fertilization." The work of Shull (9), East (7), and others on corn demonstrated that the self-fertilized corn plant was inferior in size, vigor, and productiveness, although these may remain fairly constant after a number of years of self-fertilization. This has been the cause of the general belief that self-fertilization of naturally cross-fertilized species would result in decreased vigor.

Cummings and Stone (5) working with the Hubbard squash concluded that neither self-pollination nor intercrossing were influential in controlling yield, but seed selection was effective. Bushnell (1) did not encounter inherited self-sterility in the inbreeding of the Hubbard squash to isolate pure lines, and since successful pollinations were made under a wide range of weather conditions, at any time of the day and at any time during the full bloom, the author concluded that physiological differences between flowers at time of blooming determined whether the pollination was or was not successful. The same author (2) found that the inbred lines of Hubbard squash averaged less than 5 percent lower yield than commercial checks and that their hybrids produced nearly the same yields as the checks. He concluded that "inbreeding has isolated uniform strains without marked loss of vigor and hybrids between these inbred strains show a correspondingly small increase in vigor."

Cummings and Jenkins (4) comparing an open-pollinated line, a high quality selfed line and a low quality selfed line of Hubbard squash over a ten-year period came to the conclusion that no ill effects resulted from inbreeding. Vigor and reproductive capacity were maintained without intercrossing. The average number of leaves and the average length of vine of the commercial variety increased slightly while the "selfed" lines decreased in this respect.

Reproductive capacity was maintained as shown by a gain in average number of squashes per vine, in the weight of squashes, and in the number of viable seed. Rosa (8) observed the effect of inbreeding in the second inbred generation of the Salmon Tint melon when compared with the open-pollinated strains. No constant differences were noted in flesh color, carpel number, season of ripening, or sex arrangements of the flowers. However, differences were found in yield of seed, average weight per seed, and the degrees of development of sutures and ribs.

Three commercial strains of the variety were secured in 1922, from which the foundation stock of our inbred lines was secured. Only those inbred specimens were saved each year which were fairly true to type, color, and size. The specimens which fulfilled these requirements were subjected to a "bake-test" and only those saved which were of fine texture, good color of flesh, pleasing flavor, free from stringiness, and not watery. No attention was paid to the yield of the vines from which the inbred lines were selected. When blossoms were "selfed" on a vine the remaining open-pollinated ones were removed, because it was found that a greater percentage of the "selfed" blossoms set fruit when this practice was followed. Consequently there were no means of observing whether the inbreds came from high or low yielding vines.

In the spring of 1928 six inbred lines were selected for planting on which no "selfs" were to be made during the growing season. The yielding capacity of these lines were unknown and were selected at random. The three commercial lines from which the inbred lines were secured were planted as checks. The seed was sown in hills spaced nine feet apart each way. The plants were thinned to one plant per hill when the first two true leaves were about the size of the palm of the hand.

The yields were taken on September 20 just previous to the first killing frost. The fruits were classified as mature and immature by the color of the skin. A mature Table Queen squash has a very dark green or almost black skin, while the immature fruits are lighter green and usually are smaller, although color of skin rather than size was taken as an index of maturity.

TABLE I—COMPARISON OF THE SIZE OF THE FRUIT AND YIELD OF EACH INBRED AND COMMERCIAL LINE

Line	No. of Vines	No. Mature Fruits per Vine	No. Immature Fruits per Vine	Average Wt. Mature Fruits in Ounces	Average Wt. Immature Fruits in Ounces	Total Wt. Mature Fruits per Vine in Pounds
Inbred I	8	21.5	7.9	20.50	14.40	27.6
" II	8	29.0	5.2	20.29	13.40	36.6
" III	9	24.8	5.3	23.41	11.73	36.4
" IV	8	12.9	1.1	25.82	15.56	20.1
" V	9	22.0	2.7	26.10	13.38	36.2
" VI	9	15.8	3.1	24.77	13.00	24.7
Commercial 17	10	10.8	0.8	22.33	13.50	16.7
" 28	10	14.4	2.9	21.14	12.52	16.4
" 29	10	12.8	0.6	21.07	14.83	19.6

From Table I it is seen that the average number of fruits per vine was higher in five of the six inbred lines than in the three commercial lines. The number of immature fruits as a rule was greater in the inbred lines. However, commercial strain No. 28 had more immature fruits than inbred lines IV and V. If the growing season had been longer a still greater difference in number of fruits might be expected in favor of the inbred lines. The total weight or yield of mature fruits as shown in column seven is higher in every inbred line than in any of the three commercial lines.

TABLE II—DETAILED ANALYSIS OF TWO TYPICAL INBRED LINES COMPARED TO A TYPICAL COMMERCIAL LINE

Vine No.	Inbred Line IV		Inbred Line V		Commercial Line 29	
	No. Mature Fruits per Vine	Average Wt. Mature Fruits in Ounces	No. Mature Fruits per Vine	Average Wt. Mature Fruits in Ounces	No. Mature Fruits per Vine	Average Wt. Mature Fruits in Ounces
1	12	24.00	43	28.44	7	20.71
2	13	24.92	27	26.11	28	21.50
3	16	26.00	19	25.63	16	19.12
4	10	23.50	12	24.58	19	26.37
5	17	27.35	19	25.63	19	23.68
6	12	27.17	20	24.95	7	18.29
7	12	27.50	25	24.92	8	20.37
8	11	25.73	17	28.59	10	18.10
9			16	26.12	16	23.88
10					10	19.43

In Table II it is seen that the variation in the average weight of the individual fruits is much less in the inbred lines than in the commercial lines. This is to be expected since the inbreds saved each year depended first on the external characteristics of the fruit. Only those "selfs" were saved which were of the desirable size and color and were typical specimens of the variety. On the other hand, the table shows that there may be a great deal of variation in the number of fruits between the vines in the same line. Inbred line IV is probably homozygous as to fruit size and nearly so as to the number of fruits. Inbred line V, however, shows a wide range in number of fruits per vine, although it is probably homozygous for fruit size. Commercial line 29 is neither homozygous as to fruit size nor number of fruits per vine.

TABLE III—COMPARISON OF ALL INBRED AND COMMERCIAL LINES

	Average Wt. per Fruit in Ounces	Mean No. Fruits per Vine		Mean Wt. per Vine in Ounces	
		Mature	Immature	Mature	Immature
All inbred lines.	23.23±0.11	21.0	4.2	487.9	56.2
All commercial lines.	21.68±0.14	12.7	1.4	274.6	18.7
Differences.	1.55±0.17	8.3*	2.8*	213.3*	37.5*

*Probable error is not figured since the differences are so great.

The average weight of the fruit was larger in all inbred lines as compared with the commercial lines. The inbred lines had more mature and immature fruits per vine than the commercial lines, the fruit was

larger, and the total yield per vine was higher. No attempt has been made to isolate pure lines of high or low yielding capacity similar to that of Cummings and his co-workers, but one can readily see from the data presented that pure lines of high yielding capacity may readily be secured.

In conclusion it may be said that it is possible to build up a pure line of the Table Queen squash with fruits of uniform size, shape, and quality without diminishing their size. The next step will be to secure uniformly high yielding strains. This will be comparatively easy since other desirable characteristics are already homozygous. Inbreeding may not necessarily decrease the vigor and yielding capacity of the squash or pumpkin. This is an advantage to the breeder because it is not necessary to maintain hybrid vigor after inbreeding, which would be a tremendous task.

Literature Cited

1. Bushnell, J. W. The fertility and fruiting habit in Cucurbita. Proc. Amer. Soc. Hort. Sci., 17:47–51. 1920.
2. ———. Isolation of uniform types of Hubbard squash by inbreeding. Proc. Amer. Soc. Hort. Sci., 19:139–144. 1922.
3. Castetter, E. F., and Erwin, A. T. A systematic study of squashes and pumpkins. Ia. Agr. Exp. Sta. Bul. 244. 1927.
4. Cummings, M.B., and Jenkins, E. W. Pure line studies with ten generations of Hubbard squash. Vt. Agr. Exp. Sta. Bul. 280. 1928.
5. Cummings, M. B., and Stone, W. C. Yield and quality in Hubbard squash. Vt. Agr. Exp. Sta. Bul. 222. 1921.
6. Darwin, Charles. The effects of cross and self fertilization in the vegetable kingdom. p. 8, p. 439. John Murray, London. 1888.
7. East, E. M. Inbreeding in corn. Conn. Agr. Exp. Sta. Rpt., 419–428. 1907–8.
8. Rosa, J. T. Results of inbreeding melons. Proc. Amer. Soc. Hort. Sci., 24:79–84. 1927.
9. Shull, G. H. A pure line method of corn breeding. Amer. Breed. Assn. Rpt., 4, 296–301. 1908.

Chromosome Characteristics of *Malus Ioensis* and One of Its Large Fruited Forms

By T. J. Maney and W. A. Welter, *Iowa State College, Ames, Iowa.*

CONSIDERABLE difference of opinion exists among horticulturists in regard to the correct botanical classification of some of the large-fruited types of the indigenous *Malus* species which from time to time have been discovered growing wild in various localities of the Mississippi Valley States. Some authorities consider these simply as types of *Malus ioensis* or *Malus coronaria*. Others contend that they are hybrids resulting from crosses of the native species and the common apple. Bailey in 1891 gave the Soulard crab, one of these large-fruited types, the rank of a new species—*Pyrus soulardi*, and Britton and Brown in 1897 also recognized it as such with the designation of *Malus soulardi*. Later, Bailey, in his "Evolution of Our Native Fruits" changed his opinion and stated his belief that this type was a hybrid of *Pyrus ioensis* and the common apple. Perhaps the best and most interesting account of the various large-fruited indigenous apples is given by Greene (1) who made an extensive study of practically all the known types.

The Mercer County crab, one of the best known of the large-fruited native types, originated in Mercer County, Illinois, and was introduced by N. K. Fluke, of Davenport, Iowa, about 1886. The Pomology Section formerly had this variety in its collection and grew from it a number of open-pollinated seedlings, among which is one which shows exaggerated size development in practically all its external characteristics. To all appearances this tree is a gigantic native crab. The fruit has the dull green color, the greasy skin, the rich aroma, and the strong astringency of the native crab. It differs widely from the native in fruit size and core structure. The seedling type is often as large as 3½ inches in diameter, and the core resembles that of the common apple. These marks of dissimilarity are very clearly shown in the accompanying cuts.

The form of the tree, the color of the bark, the type of growth in spurs and branches, the form and texture of leaf and the color and perfume of the flowers all remind one strongly of the native crab, except that all of these characteristics are excessively developed in size, which to the writers raised the question as to whether this development might be the result of some form of chromosome aberration, especially tetraploidy. Cytological work on the developing buds was begun in the spring of 1927; the buds were collected at various times, commencing at bud swell and continuing until the blossoms began to separate in the cluster. The most favorable time for making chromosome counts was found to be when the individual buds were about 1/8 inch in length. The killing of the tissue was carried out in Bruin's fluid. The imbedding was done in paraffin. Sections were cut from 7 to 10 microns thick and were stained in Haidenhain's iron haematoxylin.

Chromosomes were counted both at diakinesis and metaphase. Counts were more easily made at diakinesis as the individual chromosomes were separated from each other, while at metaphase they lay very close together. *Malus ioensis* was found to have 14 pairs of chromosomes. This is not in agreement with the work of Rybin (1) who reports 65 chromosomes in the root tips. The number in the Mercer County seedling was somewhat variable, 13 to 15 pairs being found. Many cases of abnormal development were observed in this type. Some of the chromosomes lagged at the equator forming nuclei of their own so that five and six microspores in a tetrad were not unusual. Shoemaker (3) reports a similar instance in the case of Stayman Winesap. The size of these microspores varied greatly; some were almost twice as large as others. The results of these chromosome counts show that the exaggerated size characteristics of the Mercer County seedling is not the result of tetraploidy. It is more probable that this seedling is simply the result of hybridization of the Mercer County crab with some common apple variety which has resulted in an excellent example of heterosis. Crandall (4) in a recent publication shows that it is possible to cross the Mercer County crab with a number of standard varieties.

Literature Cited

1. Greene, Laurenz. The indigenous apples of the United States. M.S. Thesis. Iowa State College, Ames, Iowa. 1909.
2. Rybin, V. A. Cytological investigations of the genus *Malus*. (Russian with English Resume). Bul. App. Bot. and Plant Breeding, 16:187–200. 1926.
3. Shoemaker, J. S. Pollen development in the apple with special reference to chromosome behavior. Bot. Gaz., 81:148–172. 1926.
4. Crandall, C. S. Native crabs: their behavior in breeding. Ill. Agr. Exp. Sta. Bul. 311. 1928.

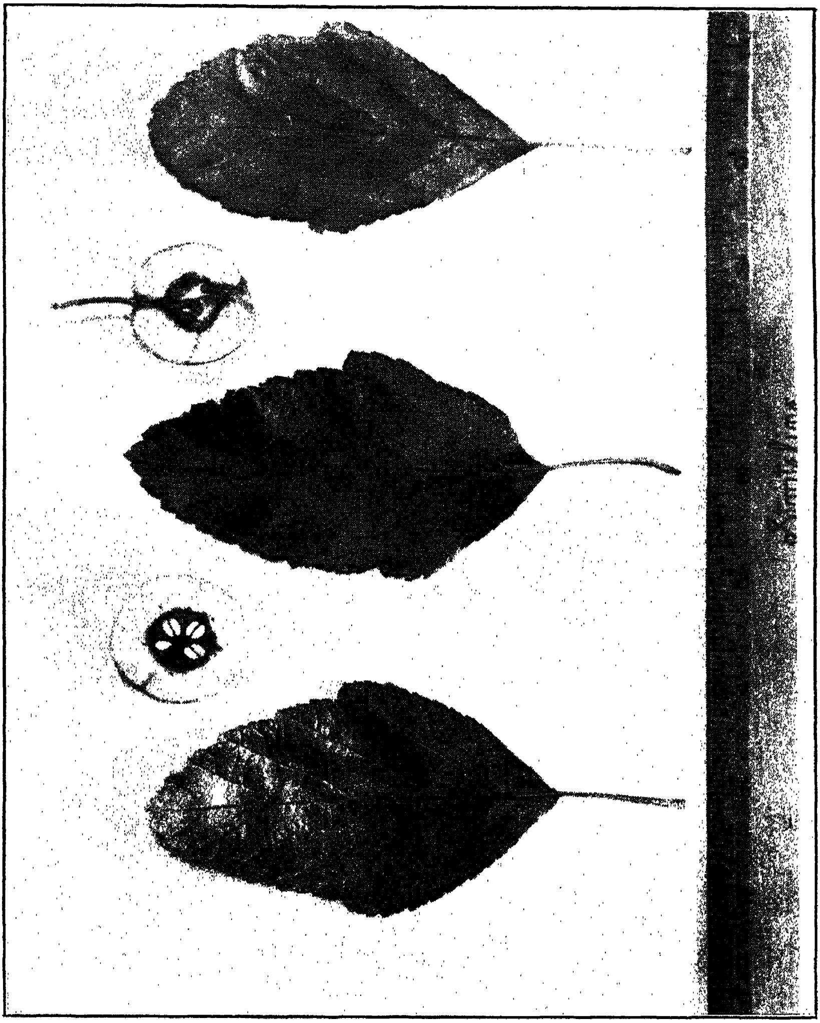


FIG. 1. *Malus ioensis:* typical size and form of leaves and fruit.

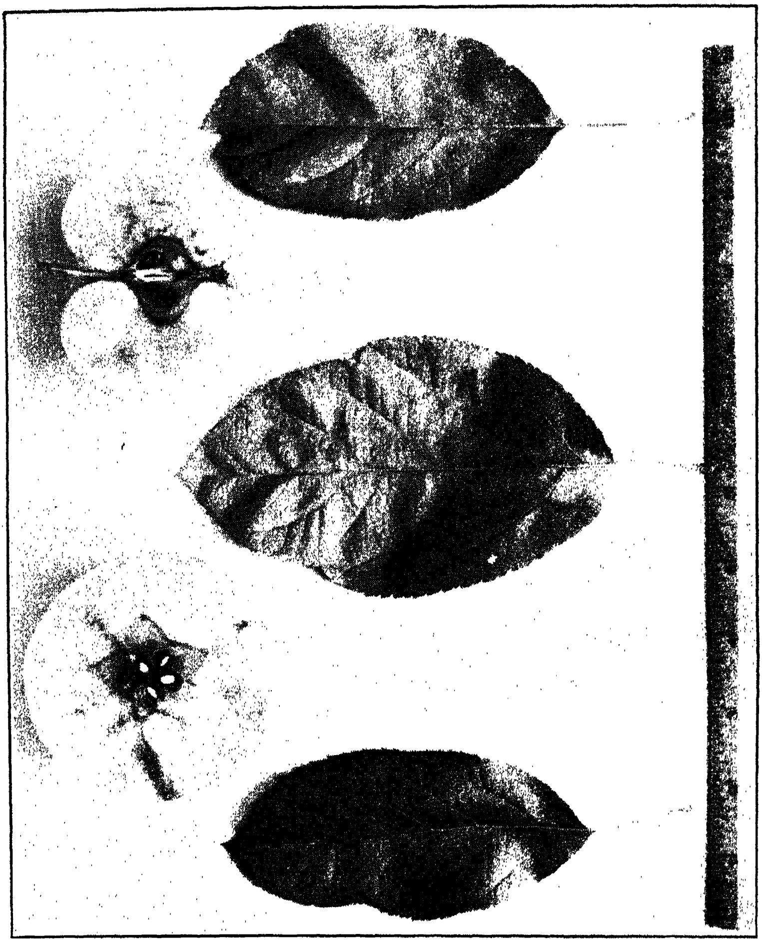


FIG. 2. Open-pollinated seedling of Mercer County Crab.

Progress in Apple Breeding in Canada

By W. T. Macoun, *Central Experimental Farm, Ottawa, Can.*

A FEW men in Canada had done some work in the breeding of apples before the Government Institutions were established. The Crimson Beauty had been originated by Francis Peabody Sharp of Woodstock, New Brunswick, and the Ontario Apple, a cross of Northern Spy and Wagener, by Charles Arnold, Paris, Ont. These two varieties are still in commerce. Peter C. Dempsey, Albury, Ont., had originated the Trenton and Walter apples.

The first effort on the part of the Central Experimental Farm, Ottawa, was the sowing of seed of Russian apples in 1889, from which 3000 trees were set out, a large proportion of which fruited. From this work, the only variety that is worthy of mention is the Rupert apple, a little earlier and a little better in quality than Yellow Transparent, and very suggestive of Early Harvest.

The next work was the crossing of the Siberian Crab, *Pyrus baccata*, with some of the named varieties of Russian apples in 1894, and with American varieties in 1895, to obtain hardier sorts for the Canadian Prairies. The largest fruits of the first generation were less than two inches in diameter. These, re-crossed with the apple, gave fruits as large as two and one-half inches in diameter, but none of these have, so far, proved as hardy as those of the first generation, of which the Osman and Columbia have been found hardy practically everywhere they have been tested in Canada, and have, in more recent years, been used as parents in continuing breeding apples, especially for the Prairies. Nearly all of the fruit from the F_1 generation retained the crab characters of long, slender stem; thin, tender skin; and firm, crisp, breaking flesh. While most of the varieties from the F_1 generation re-crossed with the apple had crab-like flesh, a small proportion had flesh like the apple. Later work with *Pyrus baccata* as the male parent gave practically the same results as the reciprocal cross so far as size of fruit and character of flesh are concerned.

The breeding of apples for the Prairie Provinces, or coldest parts of Canada, is now being conducted by institutions on the Prairies, reference to which will be made later.

A few hand pollinated crosses were made at Ottawa in 1895 for the purpose of originating a hardy winter apple for the colder parts of Ontario and the milder parts of the Province of Quebec, but nothing outstanding came of this. The parents, while hardy, were not high in quality, and none of the varieties proved promising, though winter apples were produced, as planned, when the crosses were made. It may be stated in passing that when this work was done there were only five known late keeping apples that could be depended on for hardiness at Ottawa, whereas there are now over 300 as the result of the breeding work there during the past 33 years. These winter varieties are being sifted out from year to year.

Since 1898, when cross-breeding with better varieties was begun, 253 different combinations have been made with 66 different varie-

ties. It has been the aim to make as many combinations as possible rather than to have large numbers of a few varieties, though larger numbers of all these combinations would have been used had land been available for the trees.

Following, in alphabetical order, is a list of the parents used at Ottawa: Anis, Anisim, Antonovka, Baldwin, Barnack Beauty, Baxter, Bethel, Bingo, Cellini, Charlamoff, Cobalt, Cox Orange, Crimson Beauty, Crusoe, Danville, Delicious, Duchess, Dudley, Dyer, Elmer, Esopus, Fameuse, Forest, Gano, Glenton, Golden Russet (American), Gravenstein, Grimes, Hibernal, Jonathan, King David, Langford Beauty, Lawfam, Lawver, Lobo, Lowland Raspberry, McIntosh, McMahan, Melba, Malinda, Milwaukee, Newton, Niobe, Northern Spy, Northwestern Greening, Patricia, Peach (Montreal), Pedro, Red June, Rhode Island Greening, Rosalie, St. Lawrence, Salome, Scott Winter, Shiawassee, Stone, Swayzie, Tompkins King, Wagener, Walton, Wealthy, Winter Rose, Winter St. Lawrence, Yellow Bellflower, Yellow Transparent.

In a short paper, it is not possible to go into great detail in regard to the results obtained, but those where McIntosh was used as a parent are so striking that more should be said about them than others, and, first, reference will be made to results from open pollinated McIntosh.

There were 159 trees planted from seed saved in 1898. No less than 69, or 43.39 per cent, bore fruit so good in quality and attractive in appearance that it was considered desirable to propagate them for further study. Of these, 27 varieties, or 16.98 per cent, were thought of sufficient promise to name, and, among these, are the Melba, Joyce, Macross, Hume, and Lobo, which have won very favourable comment from those who know and have grown them. In marked contrast to open pollinated McIntosh, take 95 trees of Fameuse, supposed to be the female parent of McIntosh, seed of which was also sown in 1898. While 21, or 22.11 per cent, were propagated, only a single one, the Herald, was thought worth naming, or but 1.05 per cent.

While these were uncontrolled crosses, the great value of McIntosh as a parent is shown when both parents are known. Following are the names of the varieties that have been crossed with McIntosh at Ottawa: Anis, Anisim, Baxter, Bethel, Charlamoff, Cox Orange, Crimson Beauty, Crusoe, Delicious, Duchess, Dudley, Esopus (Spitzenburg), Fameuse, Forest, Gravenstein, Grimes, Hibernal, Jonathan, King David, Lawver, Lobo, Malinda, Melba, Milwaukee, Newtown, Niobe, Northern Spy, Pedro, Scott Winter, Stone, Tompkins King, Wagener, Wealthy, Yellow Transparent,—34 varieties.

It may be said that in every case, except Baxter, the F_2 generation, where McIntosh was used as a parent, averaged considerably better in quality than the other parent, and maintained or improved the colour, but, in most of the crosses which have fruited, the other parent was much inferior to McIntosh in quality.

No trees have yet fruited of the crosses between McIntosh and Cox Orange, Delicious, Grimes, Jonathan, or Northern Spy, but,

from our experience, where the other parent crossed with McIntosh has been good quality, there should be some fine things from, at least, some of these combinations.

Notes on the general character of the fruit from those McIntosh crosses which have fruited may be given.

McIntosh and Anis.—Fruit too small, though highly coloured. Some good in quality.

McIntosh and Anisim.—Fruit too small, though highly coloured. Quality low.

McIntosh and Baxter.—Fruit highly coloured, but quality low.

McIntosh and Milwaukee.—Fruit highly coloured and good in quality. Those named from this cross are Miltosh, Toshkee, Milmac, Keetosh.

McIntosh and Newtown.—Fruit of good quality, but too small. Newtosh is the name given to the best of this cross.

McIntosh and Stone.—Fruit of good colour and good quality, but, because of lack of wax in skin, wither quickly. Stonetosh is name given to the best.

McIntosh and Forest.—Firm fleshed, good keeper, and good in quality, though somewhat dull in colour. Macfor, Toshfor, and Fortosh are those that have been named.

McIntosh and Lawver.—There has been a larger population of crosses between these parents than any of the others. There are many symmetrical, highly coloured, late keeping varieties among these, and a few that are good in quality, though not of high enough quality to compare favourably with varieties on the market already. Those that have been named are Lawmac, Lawtosh, Maclaw, Macver, Mavis and Vermac. They are all highly coloured and long keepers.

McIntosh and Wealthy.—This is one of the most promising crosses. Few trees have yet fruited, but fruit is symmetrical, highly coloured, and good in quality. The best has been called Logsdail.

When crossed with crab apples, McIntosh has made a great impression so far as colour and quality are concerned. Certain F_1 crosses of McIntosh with *Pyrus baccata* and *Pyrus malus*, and especially the varieties known as Prince and Pioneer, were crossed with McIntosh as the male parent, and gave fine varieties, certain of which have been named McPrince, Piotosh, Printosh, Rosilda, and Toshprince, all crab apples of large size, high colour, and good quality.

McIntosh and Scott Winter.—The fruit is too small, but colour and quality are good.

McIntosh and Malinda.—There was a great improvement in colour over Malinda, and the fruit was, in most varieties, long keeping, but the quality of Malinda was not raised sufficiently.

McIntosh and Crusoe.—There are some fairly promising seedlings from this cross, whereas Crusoe, with other parents, has not given any that were promising.

The best varieties, so far, have come from open pollinated McIntosh.

Other apple breeding in the Province of Ontario is carried on at the Ontario Agricultural College, Guelph, and the Horticultural Experiment Station, Vineland, Ont. Information furnished by these institutions follows.

Ontario Agricultural College, Guelph, Ont. Trees near or in bearing 400; younger trees 1377; trees removed after trial within the last three years 400; crosses made 1928, 1198; number of different combinations 26; McIntosh used 13 times, one repetition; Northern Spy used 5 times, one repetition; various Seedlings (own) 7 times, mostly selfed but no back crosses. The following varieties were used two or three times:

Wealthy, Wagener, Ribston, Fameuse, Salome, and Tompkins King, while Baxter, Duchess, Whitney, Cox Orange, Pike, Langley, and Ontario were used once each. There are 100 or more trees each in bearing of Wealthy x Wagener, Wealthy x McIntosh, McIntosh x Northern Spy, and Ontario x McIntosh. One McIntosh seedling of the season of Wealthy has been sent out for trial.

Horticultural Experiment Station, Vineland, Ont. This Station's main activities had been in other directions until recent years. The following figures give, however, some indication of the progress of the work with apples. 1924 Breeding: Salome x McIntosh, 70 trees; Bjorkman x McIntosh, 3 trees; Windsor Chief x McIntosh, 12 trees. 1925 Breeding: Rome x McIntosh, 3 trees; Jonathan x Wealthy, 15 trees; Jonathan x McIntosh, 33 trees; McIntosh x Jonathan, 6 trees; McIntosh x Grimes, 24 trees; Wealthy x McIntosh, 6 trees. 1926 Breeding: Salome x Cox Orange, Salome x Jonathan, and Salome x McIntosh, 2000 trees. 1928 Breeding: McIntosh x Jonathan, and McIntosh x Delicious, 1928 seed not yet planted. Open pollinated seed of 10 varieties, in 1918, and of 60 varieties, in 1920, to test value of varieties as parents, should begin fruiting in 1929. It is planned to use Cox Orange extensively. The main objective, in the apple breeding work at Vineland, is to obtain late keeping varieties with good colour, quality and attractiveness, combined with resistance to scab.

University of Saskatchewan, Saskatoon, Sask. The breeding of apples in Canada is now being done on the most extensive scale at the University of Saskatchewan, Saskatoon, Sask. The object of this work, as at other places and by other institutions on the Prairies, is to obtain hardier varieties of good size and quality especially adapted to the climatic conditions in the Prairie Provinces. Following are some figures from Saskatchewan University, which will give some idea of what has been done there, in recent years, since the breeding of apples was begun.

The total number of crosses made with the apple there is 249,185. The maximum number of crosses made in one season was in 1927, when 82,540 were made. The total number of seedlings living in 1928, from hand pollinated crosses, is 87,350 trees. This does not include

the seedlings which will be grown from the crosses made in 1928. In addition to the trees from the controlled crosses, there are growing 42,500 seedlings of the apple from uncontrolled crosses.

The female parents used have been the Siberian Crab and the hardiest of the Saunders hybrid crab apples, such as Osman, Columbia, Prince, Charles, Tony, and Magnus. The apple varieties which have been used as male parents are McIntosh, Melba, Wealthy, Duchess, St. Lawrence, and Yellow Transparent. Much of the crossing done has been in the orchard of the Experimental Station, Rosthern, Sask., where nearly all the female parents are growing. The Rosthern Station is now beginning the cross-breeding of apples.

Experimental Station, Morden, Man. The largest collection in Canada of the hardiest varieties of apples and crab apples is at the Dominion Experimental Station at Morden, Man. The trees of many of these varieties are now bearing, and are furnishing excellent material for cross-breeding, and during the past few years considerable breeding work has been done. So far 106 different combinations have been made, from which have resulted 3,000 seedlings, none of which has yet fruited. The names of the principal apples and crab apples used in breeding work are: Angus, Anisette, Blushed Calville, Columbia, Crimson Beauty, Dolgo, Duchess, McIntosh, Piotosh, Red Astrachan, Trail, Wealthy, Yellow Transparent. In addition to the controlled crosses, there were planted, in 1916, some 27,000 open pollinated seedlings of the hardiest Russian and other varieties of apples. Several thousands of these have fruited, and many have been propagated for further and more extended test on the Prairies.

Experimental Station, Summerland, B. C. Longer keeping and good shipping apples of the McIntosh type are needed in British Columbia, and the breeding work at the Summerland Station, begun in recent years, has this for the main object of the work. The parents used with a view to obtaining the kind of fruit desired are McIntosh, Newtown, Winesap, Delicious, Golden Delicious, Rome Beauty, and Grimes Golden. As a result of the work to date, there are 242 seedlings four years of age and 150 seedlings three years old. In addition, there are over 1,000 two-year-old trees not yet set out in fruiting rows. Twelve combinations have been made, using McIntosh, Newtown, and Delicious mainly. None of the trees have yet come into bearing.

In addition to the foregoing, open pollinated seedlings are being grown at the Experimental Stations at Scott, Sask., Indian Head, Sask., Dominion Forestry Station, Indian Head, Sask., and the Experimental Station, Fredericton, N. B., while a number of private individuals are breeding apples also.

It is estimated that the total number of apple trees grown for breeding purposes by and at various institutions in Canada during the past 38 years is 226,376.

The time should not be far distant when there will be varieties of apples originated in Canada suitable for all parts of Canada where there is settlement, in season throughout the year, and comparing favourably with those of any other country. The results of the work

in Canada are gladly shared with horticulturists in the United States and other countries to whom plants and scions of promising varieties are sent.

From our experience in breeding apples in Canada, we have reached the following conclusions.

1. To originate a hardy apple for places where no apples or improved crab apples have yet been found hardy, (a) cross the apple with the wild Siberian crab apple (*Pyrus baccata*), and re-cross the hardiest F_1 with the apple; (b) sow seeds of apples which are hardy in a climate as nearly similar as possible.

2. To originate apples having certain characteristics such as hardiness, vigor, and productiveness of tree, and quality, size and appearance of fruit, cross varieties having most of the characteristics desired.

3. If seedlings are to be grown on a large scale, more varieties having the characteristics desired will be obtained if trees of several named sorts, blossoming at the same time, be planted in close proximity in the orchard, and the seeds used from fruit borne on these trees.

4. In cross-breeding apples, when quality is an important factor, cross two varieties which are both good or very good in quality. It has been the experience at Ottawa that, in crossing a variety of good quality with one of inferior quality, the F_1 generation will nearly always bear fruit with quality inferior to the one with good quality.

5. Use parents which have been found by breeders to be prepotent.

Taming the American Wild Crabapple

By N. E. Hansen, *State College, Brookings, South Dakota*

The commercial apples of the present day have a complex pedigree being descendants of species native to the temperate parts of Europe, and Asia.

The heterozygous character of the standard varieties is clearly evident from the experiments in apple-breeding in many states. Apparently no rules or general principles can be formulated from the results. Good apples have poor offspring, and poor apples have good offspring. There is much sterility and weakness of pollen in some standard apples, indicating a too complex chromosome structure. One of my plum seedlings, a combination of four species, proved to be practically sterile.

From experiments covering the past thirty-three years in breeding many fruits, including the apple, plum, cherry, pear, grapes and small fruits, I have made the deduction that homozygous parents give uniformly better results than heterozygous parents. This I announced in my paper "The Relative Value of Homozygous and Heterozygous Parents in the Breeding of the Apple, Plum, Cherry, Grape and Other Fruits" prepared for the Fifth International Congress of Genetics, Berlin, August, 1927.

The Hansen Hybrid plums, as they are termed by the nurserymen, are now grown in many western states. Sapa, one of the most popular hybrids, is a hybrid of two homozygous species, *Prunus Besseyi* and *Prunus triflora*. The Waneta and Kahinta plums, the largest hardy hybrids, full two inches in diameter, are *Prunus triflora* x *P. Americana*.

In old apple orchards, the best results are not obtained in spraying, because the trees are too large. Smaller trees, planted closer together, would be easier to spray. In pears, quince stocks give us dwarf pears. But in apples, if the apple itself could be dwarfed somewhat, the problem would be solved. It would bring earlier bearing. Such trees could be planted closer together.

Too much labor, especially in pruning, is required with Doucin and French Paradise stocks to make them available for general use in America. The trees overgrow at point of union. There are other reasons also.

Smaller size and earlier bearing in the most recent light of heredity, must be considered as unit characters. The apple must be taken apart and put together again, genetically speaking, to secure the new varieties better adapted to modern conditions. As has been done with Indian corn, we should reduce the apple to a homozygous state for greater hybrid vigor in new combinations. Since selfing appears very difficult in the common apple of commerce we can work with the indigenous apples of America—the only apples the Indians knew before the white man came.

The past season, many more of my hybrids of *Pyrus Ioensis*, our wild western apple, with *Pyrus malus* fruited. All of them are noted for early bearing, smaller size of tree, resitance to fire blight and the fruit keeps till apples come again. The necessary quality and size of fruit do not come until they are crossed back to the apple, as in my Anoka, now widely popular. This bears annually on one-year-old wood and begins bearing the second year after planting a one-year-old budded tree. The Anoka is probably the earliest and heaviest bearing hardy apple in the world today.

The Redflesh crabapple is another result of this work with the wild crabapple. The color is a brilliant red and the flesh is red throughout. The fruit is of good size and makes excellent red jelly and preserves. The abundant red blossoms makes the tree very ornamental as well as useful. This variety was introduced this year, 1928, and seems destined to wide popularity. The pedigree is *Pyrus malus Niedzwetzkyana* x Elk River wild crab.

The question of hardiness I have tried to solve as far as possible by working with the wild crab as found at Nevis, northern Minnesota, the furthest northwest this species has been found growing wild. Also with the wild crab as found at Elk River, some forty miles north of Minneapolis, Minnesota. The first of these Elk River hybrids are recorded in South Dakota Bulletin No. 224.

In apples, I hope that this work will be followed up by many investigators, so that within the next few years we may see a new race of late winter-keeping apples of early and annual bearing, free from fire blight and of good size and choice quality, and of the right size for convenient spraying.

Further Notes on Peach Breeding

By C. H. Connors, *Experiment Station, New Brunswick, N. J.*

FROM time to time, there have appeared in the proceedings of this society, the results of the work with peach breeding carried on at the New Jersey Agricultural Experiment Station (1, 2, 3, 4). Following the last report, there appeared in one of the journals a severe criticism on the unreliability of "genetic" studies in the orchard with tree fruits, aimed in part at this peach breeding work. In order to clear this matter, certain statements should be made.

Peach breeding cannot be called a genetic study, in the accepted sense of the word, because (1) the peach is a plant bearing hermaphroditic flowers, and propagated usually by vegetative means, generally heterozygous; (2) it requires a minimum of five years to produce a generation; and (3) there are at least five points where errors may enter, namely, at time of pollination, at time of harvest, at time of planting the seeds, at time of setting in the nursery, at time of setting in orchard; the second being the most critical.

The primary object of a study such as this is to secure varieties of fruits which are superior to those in existence. Any knowledge as to the behavior of certain characters in breeding is incidental, but of course, is valuable in the further pursuit of the work. The point which it is desired to make is this: We should recognize that there is a field in breeding which has as its primary consideration the improvement of existing varieties, which would leave the field of genetics free to those who are studying fruit flies or annual flowering plants propagated normally by means of seed.

It might not be amiss at this time to give a summary of the facts that have been gathered.

Tree Habit: In general, white fleshed varieties are more vigorous in tree growth than yellow fleshed sorts. The heredity of tree-habit appears to be very complex, with three general types: Upright, spreading; and intermediate, which contains all gradations between the extremes. Apparently, crosses between upright and spreading will give all intermediates, but these will be of wide range.

Foliar Glands: Crosses between varieties having reniform glands and those with eglandular leaves produce progeny with globose glands. Globose glanded varieties selfed or crossed will yield approximately one reniform, two globose, one eglandular. Eglandular leaves are most susceptible to mildew.

Size of Blossom: Large blossoms crossed with small blossoms gave all medium sized blossoms. Varieties with medium sized blossoms crossed or selfed gave progeny with the approximate proportions of one large, two medium, one small.

Sterility: No cases of incompatability have been found in these studies. Two types of sterility have been found and described (4, 5). This one is a one-sided sterility in the blossoms, exhibited as pollen abortion. The typical examples of this are J. H. Hale and Chinese Cling. This type of sterility appears also in the progeny of Belle and

Elberta. The other type of sterility is what appears to be embryo abortion in the varieties which mature early in the season, preventing the development of viable seeds, and, hence, limiting breeding to this extent.

Ripening Dates: In progenies resulting from crosses, the majority of individuals ripen their fruits about midway between the ripening dates of the parents. In progenies resulting from selfing, the majority ripen at the same season as the parent.

Color of Flesh: White flesh is dominant over yellow flesh. Yellows crossed or selfed, have yielded all yellows, homozygous whites have yielded all whites, and heterozygous whites have yielded about the proportions of three whites and one yellow.

Texture of Flesh: Three grades of texture only are considered, soft, firm, and tough. The first two belong to the melting flesh group, while tough is the texture characterized by such canning varieties as Tuscan. Belle and Early Crawford, when selfed, gave progeny of about one soft, two firm, one tough, while Elberta gave a very much lower proportion of tough and a higher proportion of firm. Toughness evidently behaves as a recessive, as St. John (firm) X Early Wheeler (very tough), gave only two tough, while twenty-three were too soft for shipment, and nineteen were firm.

Adhesion of Flesh to Stone: Generally, freestone X freestone gives two freestone to one cling or semi-cling, and the progeny of freestone X clingstone will vary with the ability of the freestone parent to produce freestones.

Size of Fruit: When small-fruited parents are used, small-fruited seedlings may be expected in the first generation. This has been true also when one of the parents is small and the other large.

Open pollinated seedlings of J. H. Hale, as previously reported (5), exhibited sterility of a type similar to that of J. H. Hale, in 43 cases out of 127 seedlings, or 33 per cent. Data are now available on controlled progenies of J. H. Hale.

TABLE I—Sterility in Seedlings of J. H. Hale

	Total	Dead	Bloomed	Male Sterile	Per cent Sterile
J. H. Hale x 43215 (E-G)...	117	2	106	59	55.6
J. H. Hale x Marigold (L-A)	184	0	180	86	47.6
J. H. Hale x 27116 (S-D)...	132	4	125	0	0
J. H. Hale x 32816 (C-S)...	193	0	188	0	0

It will appear that there are two classes in these progenies, one in which about 50 per cent of the individuals are sterile, and the other in which all are perfect. This type of sterility is evidently recessive to the fully fertile hermaphroditic flower form. Eleven other progenies will give data in 1929 to continue this study, six more in 1930, and nine in 1931.

Among seedlings from collected "wild" stones are found sometimes one per cent of individuals which have purple leaves. During the World War, several nurserymen propagated particularly well-

colored individuals which were sold as substitutes for Japanese Maples. If a peach tree with ornamental foliage and edible fruit could be bred, it would influence the sale of such trees to small land-owners. Elberta was crossed with one of these propagated purple-leaved forms. Seven seedlings resulted, and all of these had purple leaves. The fruits are small and insipid, but are an improvement in size and quality over the fruits of the "wild" parent. J. H. Hale was crossed with two of these individuals, and the resulting progeny consists of about one-half green-leaved sorts and about one-half purple-leaved.

Double-flowered peaches have been in the trade for many years. It has been suspected that the commercial varieties may carry a recessive factor for doubleness, but close examination of peach blossoms every spring over a period of 15 years has revealed just one completely double flower, which occurred in a seedling of Lola.

In order to test the inheritance of doubleness, Elberta was crossed with the double white form. All of the resulting 41 seedlings were white-fleshed, as was expected. Thirty-four out of these 41 seedlings produced flowers having accessory petals, in the first generation. The flowers on individual seedlings varied widely, some producing few to many partly doubled flowers. Several seedlings produced flowers having 16 petals, instead of the normal five. Part of these extra petals were of staminoid origin, while part were formed from division of the primary petals.

In a previous report (5), it was stated that no examples of cross- or selfed-incompatibility had been found in the peach. In order to learn if the pistils might have a selective power, double pollination was performed. Blossoms of Elberta were emasculated, and after the stigmas had become fully receptive, viable pollen of Elberta was applied to one side of the stigma, and, at the same time, viable pollen of an albino was applied to the opposite side of the stigma. The viability of the pollens was tested upon a sugar-agar medium.

Thirty-two seedlings resulted from the pollination. Judging from the color of the chalice, seventeen are white-fleshed from the cross with the albino, while fifteen are yellow-fleshed, resulting from the close-pollination with Elberta pollen. There is here no evidence of power in the stigma to select pollen.

Crosses have been made between J. H. Hale and *Amygdalus kansuensis*, a Chinese bush peach. This latter blooms about ten days before the commercial varieties, but is exceedingly hardy in flower and fruit, as it set a full crop one year when the temperature dropped to 26 degrees F. on two nights after bloom began. Its fruits are small and scarcely edible. The resulting seedlings made the largest growth of any progeny in the first and second years in the orchard. The hybrids top-worked on old trees bloomed at about the same time as the species the past season, set good crops, but the fruits were little, if any, larger than the species parent. The second generation may show an improvement in size. If the flower and fruit hardiness and vigor of growth can be bred into our commercial varieties, a notable improvement will be obtained.

J. H. Hale and Goldmine nectarine were crossed with a hard-shelled almond, and nearly 100 seedlings are now in the nursery. The cross of peach and almond has been made by other workers previous to this work.

One question that was put to the writer during the past year was whether progenies of 20 were not sufficiently large. The reply was that, in the project under report, progenies of at least 100 are desired, and better, 200, as in small progenies, it might happen that one character, such as tough flesh, sterility, and so on, might predominate in the individuals.

By means of correlations, it is possible to forecast certain characters, as color of flesh and fertility. In order to seucre a forecast of the productiveness and quality, it is necessary to resort to top-working. It has been found feasible to top-bud 10 to 20 or more individuals into one tree, taking buds from the seedlings in the nursery during their first year. These topworked individuals will fruit one or two years before the trees set in the orchard. By top-working 50 out of a population of 200, a very fair cross-section of the total population is obtained.

Up to the present time, 15 varieties have been named and disseminated. Eight of these were sent out as home orchard sorts, being of high dessert quality, but lacking in some respects as commercial sorts. Three varieties have already taken positions of importance in the New Jersey peach orchards. Pioneer and Cumberland are high colored, good quality varieties ripening a few days before Carman, and far superior to the latter in shipping quality. Eclipse is a yellow Hiley. Golden Jubilee is being distributed in large numbers this year, and should prove a notable addition to the variety list. It is a yellow freestone of good quality, resembling Elberta in external characters, but ripening just before Carman.

These varieties will all be supplanted within a few years. The seedlings resulting from the breeding work of 1923 fruited this year, and elimination trials left about 75 out of 1200 standing in the orchard. Among these will be white and yellow fleshed sorts, resembling J. H. Hale in flesh characters and quality, but ripening from before Carman up to the time of Elberta. These are largely J. H. Hale crossed with own seedlings of proven merit. Progenies to cover the period of Elberta and two weeks later are now in the orchard and nursery.

Literature Cited

1. Connors, C. H. Some notes on the inheritance of unit characters in the peach. Proc. Amer. Soc. Hort. Sci., 23. 1919.
2. ———. Inheritance of foliar glands of the peach. Proc. Amer. Soc. Hort. Sci., 20. 1921.
3. ———. Peach breeding—a summary of results. Proc. Amer. Soc. Hort. Sci., 108. 1922.
4. ———. Fruit setting in the J. H. Hale peach. Proc. Amer. Soc. Hort. Sci., 147. 1922.
5. ———. Sterility in peaches. Mem. Hort. Soc. N. Y. 3: July, 215. 1927.

Pollination Studies in New York State

By L. H. MacDaniels, *Cornell University, Ithaca, N. Y.*

It has long been realized that the interpretation of the results of pollination experiments in terms of commercial yields is very difficult. This is in part because of the many nutritional and other environmental factors which affect the set of fruit aside from pollination and which frequently have not been taken into consideration in the presentation of data, and in part because the methods employed are so diverse that it is difficult to compare the results satisfactorily. Nutritional factors have been considered by Chandler (1), Heinicke (2, 3), and others, and a discussion of methods has been carried on in part by Chandler (1), Howlett (5, 6), Knowlton (7), and MacDaniels (8).

In the present work two methods were used. In the first, trees were caged with bees, in some cases for the purpose of selfing the variety caged, and in others for crossing the caged variety by distributing pollen from introduced "bouquets" of blossoms of the pollen variety. The ability of the caged tree to set was checked by bagging limbs about 10 centimeters in circumference and applying some good pollen, such as Delicious, by hand. The effectiveness of the bees in pollen distribution was checked on the trees to be cross-pollinated by hand-pollinating similar limbs with pollen from the introduced bouquets. The cage method is of special value in testing the self-sterility of a variety as there can be no question but that the blossoms are thoroughly selfed. When the caged tree is to be cross-pollinated from introduced blossoms, there may be some uncertainty as to whether or not the pollen is thoroughly distributed. One of its most serious limitations among those brought out previously (8) is the small number of trees that can be used. In 1928 the bees were kept in cold storage until the caged trees were in bloom and the bouquets were in place. This prevented selfing of the blossoms before they could be crossed and also prevented the bees from becoming contaminated by other pollen before they were put into the cage.

The other method employed was to select five to seven branches about 10 centimeters in circumference on each of a number of trees of the same variety. Two or three of these were left without protection from insects as checks and the others enclosed in cheesecloth bags about 3x6 feet just before the blossoms opened. When the blossoms were fully out, pollen of the desired varieties previously collected and dried was applied with a camels hair brush to all of the clusters. This method has a number of advantages. First of all, it allows the use of a number of trees in different localities. Second, the work can be done rapidly so that large numbers of flowers can be used. Third, the blossoms are under nearly natural orchard conditions as emasculation, shading over a long period of time, or enclosing in a tight bag with resulting temperature and humidity changes, does not occur. Fourth, the results are readily interpreted in terms of commercial set, as all the blossoming spurs are used and direct comparison with

the check branches is possible. In the writer's opinion, the results of any method where spurs are selected for their vigor are difficult to interpret in terms of a commercial set. On spurs so selected, a set can be obtained with even a poor pollen and a set under such conditions is not an accurate indication of the value of the pollen under average orchard management.

A good commercial set on a limb 10 centimeters in circumference is 20 to 25 fruits with large sized apples like McIntosh, R. I. Greening and Northern Spy, and 25–30 with such varieties as Baldwin and Jonathan. This figure has been determined by actual count on many limbs and although heavier sets often occur, good orchard practice would favor thinning to about the figures given. Certainly, expressing the yield in terms of the number of fruits per unit limb of this size is much more intelligible from a commercial standpoint than giving the percentage of spurs holding fruit or the percentage of pollinated blossoms setting, although these expressions have some significance.

From a more technical viewpoint it is important to know the number of growing points on the limb as this gives an indication as to whether the branch is weak and spurry or vigorous. The number of spurs blossoming is also of importance in the light of what Heinicke (2) has shown regarding the relationship of the amount of bloom and the percentage set. The number of spurs holding fruits just before the June drop may give a good indication of the value of a variety as a pollinizer, especially were unfavorable conditions, *e.g.*, drouth, insects, etc., cause abscission to be unduly heavy. The number of seeds in the mature fruit gives an indication of the relative effectiveness of the pollinizer as has been shown in a number of publications (2), (9), (10). The number of seeds in a fruit may be the determining factor in its ability to stay on the tree during and after the June drop, and although, of course, the number of seeds varies with the variety, *e.g.*, Baldwin having few and Northern Spy many, yet consistent relative differences with different pollen varieties on the same variety indicate a difference in the effectiveness of the pollen.

Results with Northern Spy

In Table I are given the results from pollination of seven Northern Spy trees. Trees 1 to 4 were in a well cared for orchard in western New York. The trees were about 20 years old, of good size and vigor, and had not borne heavy crops at any time. The block was four rows wide with Baldwin on one side and Wealthy on the other. The trees at Ithaca, N. Y., were in their eighteenth season, of fair size and vigor, and had borne consistently good crops for about 10 years.

From the data given it is evident that the variety is self-sterile under New York conditions, a fact to be suspected from results obtained elsewhere (1, 5). Delicious showed the most consistently uniform and satisfactory set, but Rome was as good for all practical purposes. Golden Delicious was sufficiently effective to be regarded as a satisfactory pollinizer. Wealthy was not so uniformly good as the others as shown by the variation in yield and also by the consistently lower seed count. On all four trees where Wealthy was tried,

the seed count was less than for Delicious and Rome. It does not follow, however, that Wealthy is not a satisfactory source of pollen for Northern Spy in the orchard, whenever it blooms at the same time, as it did in 1928.

The data also show that conditions during the blooming season in western New York were so unfavorable for pollination that unprotected blossoms failed to set a crop. A recording thermometer in a nearby orchard showed that at no time during the blooming season were conditions really favorable for the flight of bees, considering 65 degrees F. as the minimum temperature at which they fly freely. On one occasion when the temperature might not have been limiting, there was a gusty wind that interfered with flight. These conditions differ markedly from those at Ithaca where unprotected insect-pollinated blossoms set as well or better than those hand-pollinated, (branches 28, 33 and 34).

Table II gives the results from a 20-year-old Northern Spy orchard of low vigor. For a number of years the orchard had not been well cultivated or fertilized with nitrate, with the result that terminal growth was relatively short. The orchard had not borne much previously and blossoming was very heavy. Early in the Spring of 1928 sodium nitrate at the rate of three pounds to the tree had been applied and some branches had been scored by cutting through the bark at the base of the branch without removing the bark strip after the manner described by Gourley and Howlett (11). The data show a number of points of interest. First, that where pollen was not applied by hand, total crop failure followed showing that pollen had not been distributed by insects (branches 5, 6, 11 and 12). Second, although some increase in set followed the application of pollen, a commercial set was not secured because of the poor cultural conditions. Third, ringing which is known to increase the set on blossoming limbs under more favorable conditions (4) failed to make a significant difference in a nitrogen starved orchard. Fourth, much greater variation in response to pollination is found in trees of low vigor than in those growing under better conditions. Tree No. 2 shows a much smaller set with the different pollens than the other two and on all three trees Delicious gives greater variation in set than in the orchard reported in Table I. Such data emphasize the necessity of using vigorous trees, growing under good cultural conditions for pollination work if true pollen values are to be obtained.

Results with McIntosh and R. I. Greening

Data similar to that given in Table I were obtained with McIntosh and R. I. Greening, but space does not permit its publication here. Both of these varieties were self-sterile under all conditions where they were tested in this regard and with the trees in western New York both showed a poor set where pollen was not applied by hand. This is the result of the same condition as regards the lack of bees in the orchard at blooming time as that found with Northern Spy and illustrated in Table I. Cortland and Delicious pollen gave good results on McIntosh, but results with Baldwin and R. I. Greening pollen were uncertain except under unusually good conditions for setting.

TABLE I—POLLINATION RESULTS WITH NORTHERN SPY—SPRING, 1928

Tree No.	Branch No.	Protection from Insects	Pollen Variety	Circum. of Branch Cm.	Total No. of Spurs	No. of Spurs Blossoming	No. Spurs with Fruit June	No. Spurs with Fruit Sept.	No. of Fruits Sept.	Per cent Blossoming Spurs with Fruit Sept.	Ave. No. Seeds per Fruit
1 Western New York	1	Bagged	Delicious	11.5	124	68	56	31	35	45.6	11.2
	2	Bagged	Wealthy	11.2	111	41	28	20	24	48.8	10.2
	3	Bagged	Rome	9.5	95	39	30	30	33	76.9	12.9
	4	Bagged	N. Spy	14.0	94	37	0	0	0	0	0
	5	None	Unknown	10.0	115	51	6	4	4	7.8	4.0
	6	None	Unknown	9.5	122	45	3	1	1	2.2	3.0
2 Western New York	7	Bagged	Delicious	9.5	143	110	58	35	37	31.8	10.8
	8	Bagged	Wealthy	10.5	164	118	18	15	15	12.7	7.0
	9	Bagged	Rome	8.7	82	48	26	16	17	33.3	11.3
	10	Bagged	N. Spy	8.0	114	69	1	1	1	1.4	4.0
	11	None	Unknown	11.0	165	59	6	6	7	10.2	5.3
	12	None	Unknown	8.7	129	82	1	1	1	1.2	—
	13	None	Unknown	10.2	160	92	7	1	1	1.1	—
3 Western New York	14	None	Rome	10.4	89	81	56	35	36	43.2	—
	15	None	Rome	—	152	108	45	20	22	18.5	—
	16	None	Rome	8.0	57	48	27	17	19	35.4	—
	17	None	Unknown	8.2	79	72	6	4	4	5.6	—
	18	None	Unknown	8.0	60	51	8	8	10	15.7	—
	19	None	Unknown	11.5	93	56	10	8	8	14.3	—

4 Western New York	20	None	Gold. Del.	8.0	81	44	10	12	13	27.3	—
	21	None	Gold. Del.	9.0	134	46	24	17	19	36.9	10.3
	22	None	Unknown	9.0	105	51	4	4	4	7.8	—
	23	None	Unknown	8.7	94	61	1	0	0	0	—
5 Ithaca, N. Y......	24	Bagged	Rome	8.0	108	68	22	22	22	32.3	6.4
	25	Bagged	Delicious	11.2	120	84	35	35	35	41.6	6.9
	26	Bagged	Wealthy	11.0	165	106	11	11	11	10.4	5.5
	27	Bagged	N. Spy	9.2	131	82	0	0	0	0	0
	28	None	Unknown	10.5	128	60	41	40	42	66.7	7.3
6 Ithaca, N. Y......	29	Bagged	Rome	9.9	118	99	41	41	43	41.4	11.3
	30	Bagged	Delicious	11.5	142	113	38	38	39	33.6	12.5
	31	Bagged	Gold. Del.	9.5	108	96	22	22	23	22.9	10.3
	32	Bagged	N. Spy	10.3	106	42	0	0	0	0	0
	33	None	Unknown	10.0	116	34	28	22	22	64.7	9.6
	34	None	Unknown	9.3	103	86	34	31	32	36.0	6.9
7 Ithaca, N. Y......	35	Tree	Rome	10.0	144	108	50	50	51	46.3	6.9
	36	Caged	Wealthy	10.1	145	76	35	35	37	46.0	5.9
	37	with	Delicious	9.3	134	79	25	25	27	31.6	7.8
	38	Bees	Gold. Del.	11.2	158	114	36	35	36	30.7	7.5
	39	—	N. Spy	10.2	154	97	2	2	2	2.0	—
	40	—	N. Spy	8.6	122	66	0	0	0	0	0
Remainder of Tree..	7	—	N. Spy	—	7513	4890	—	158	158	3.2	2.4

*Pollen applied by hand on all limbs where pollen variety is named except in tree No. 7 where Northern Spy pollen was distributed by insects.

TABLE II—HAND-POLLINATION COMPARED WITH *INSECT-POLLINATION ON UNCOVERED NORTHERN SPY BLOSSOMS IN A WESTERN NEW YORK ORCHARD OF LOW VIGOR. SPRING, 1928

Tree No.	Branch No.	Variety of Pollen Applied	Treatment	Circum. of Branch in Cm.	Total No. Spurs	No. Spurs Blossom	No. Spurs with Fruit June	No. Fruits June	No. Spurs with Fruit Sept.	No. Fruits Sept.	Per cent Blossom Spurs with Fruit Sept.
1 Western New York	1	Delicious	Ringed	9.8	91	81	16	20	14	14	17.3
	2	Delicious	None	8.0	92	88	9	9	2	2	2.3
	3	Rome	Ringed	7.5	39	32	12	15	12	12	37.5
	4	Wealthy	Ringed	10.0	50	47	0	0	0	0	0
	5	None	Ringed	6.5	66	33	0	0	0	0	0
	6	None	None	8.5	49	42	1	1	0	0	0
2 Western New York	7	Delicious	Ringed	10.4	79	59	5	5	3	3	5.1
	8	Delicious	None	9.8	75	53	6	7	1	1	1.9
	9	Rome	Ringed	8.5	86	55	3	3	3	3	5.4
	10	Wealthy	Ringed	10.0	125	101	5	5	3	3	3.0
	11	None	Ringed	9.3	57	0	0	0	0	0	0
	12	None	None	7.5	69	39	0	0	0	0	0
3 Western New York	13	Delicious	Ringed	9.5	115	44	3	4	3	3	6.8
	14	Delicious	None	9.2	124	47	16	21	12	12	25.5
	15	Rome	None	9.0	129	111	20	16	14	14	12.6
	16	Gold. Del.	Ringed	9.4	125	89	23	33	20	21	22.5
	17	N. Spy	Ringed	9.0	52	49	2	3	2	2	4.1
	18	N. Spy	None	9.0	78	44	1	1	1	1	2.3

*Of course there is no assurance that insects actually pollinated the blossoms.

R. I. Greening set well with Wealthy, McIntosh, Cortland and Delicious pollen, but failed to set well with Baldwin on three trees at Ithaca, N. Y.

The data of Table III is of interest in that it shows that Baldwin is sufficiently self-fruitful to set a commercial crop under conditions where R. I. Greening and McIntosh failed. The Baldwin trees were in the same orchard with the Greening trees and, if anything, their location was in a less favorable position for cross pollination than the Greening in that there were possible sources of pollen along one side of the block only. The McIntosh orchard where crop failure resulted because of lack of cross pollination on unprotected blossoms was about one-half mile distant from the Baldwin block. It will be noted, Table III, that larger yields were obtained on Baldwin by hand-pollination with Delicious and Golden Delicious than on the blossoms not so pollinated. From a commercial standpoint, however, this would be of questionable advantage as 20 to 25 fruits is a sufficient load for the unit limbs chosen. That Baldwin will set a crop with its own pollen is shown also by the data obtained in 1926 when insects were excluded and the bagged blossoms brushed.

The season's work aside from the indication of the relative effectiveness of the different pollens on several important New York State varieties has emphasized the importance of the consideration of nutritional conditions in evaluating data and the necessity of using a number of trees in testing out the potency of a pollen. This is particularly true where negative results or poor sets are obtained. Under favorable conditions good sets have been obtained with relatively poor pollinizers, such as Baldwin and R. I. Greening, and under conditions unfavorable for a set, even an excellent pollen like Delicious failed to give a crop.

Before a satisfactory picture of the value of a variety as a pollinizer in a commercial orchard can be gained, it is necessary in the opinion of the writer to try it out under orchard conditions in a number of localities. If the pollen variety consistently fails to give a crop except under exceptionally favorable conditions, the value of that variety as a pollinizer is to be questioned. On the basis of experience so far, Baldwin and R. I. Greening are in this class the former giving poorer results than the latter. One is not justified in saying that these varieties are worthless as pollinizers especially if they are planted in solid rows along with a self-sterile variety. The grower on the other hand cannot consider them as satisfactory sources of pollen where a minimum number of pollinizers is to be introduced in the orchard. And in any case, if the grower is to provide for effective pollination under poor conditions for pollen transfer and fertilization, these should not be relied on as the only sources of pollen.

Another angle to the pollination situation in western New York that is all important is the liklihood of cold, windy weather at blossoming time. This season the light crop in certain sections was unquestionably due to this cause and going over the temperature records of other years shows that this condition is rather frequent. This was pointed out by Hedrick (12) in 1908 in his review of the

TABLE III—RESULTS OF HAND-POLLINATION AS COMPARED WITH †INSECT-POLLINATION ON UNCOVERED BALDWIN BLOSSOMS IN WESTERN NEW YORK. SPRING 1928

Tree No.	Branch No.	Pollen Variety	Circum. of Branch Cm.	Total No. Spurs	No. Spurs Blossoming	No. Spurs with Fruit June	No. Fruits June	No. Spurs with Fruits Sept.	No. Fruits Sept.	Per cent of Blossoming Spurs with Fruit Sept.	Ave. No. Seeds per Fruit
1.	1	Baldwin	8.6	118	55	37	67	29	36	52.7	—
	2	Delicious	7.4	108	78	54	116	45	57	57.7	1.2
	3	Gold. Del.	8.4	111	58	41	84	41	76	70.0	1.5
	4	Unknown	7.0	86	53	25	39	20	29	37.7	1.9
	5	Unknown	7.0	85	77	31	49	31	41	40.3	1.7
	6	Unknown	7.5	103	74	36	55	26	36	35.1	2.1
2.	7	Gold. Del.	8.7	130	46	24	33	22	25	47.8	3.6
	8	Delicious	9.6	168	57	40	55	40	51	70.2	3.6
	9	Unknown	8.9	161	64	19	22	19	21	29.7	2.1
	10	Unknown	8.2	149	37	22	25	22	25	59.5	2.8
3.	11	*Delicious	8.1	123	84	29	34	26	32	30.9	—
	12	Unknown	7.5	101	58	15	17	13	15	22.4	2.6
	13	*Delicious	8.2	126	93	61	91	48	58	51.6	4.7
	14	Unknown	9.0	141	123	29	35	22	24	17.9	—
	15	Unknown	8.1	97	86	44	54	32	40	37.2	—
4.	16	Unknown	9.0	127	94	37	45	34	43	36.1	2.6
	17	Unknown	9.0	134	111	40	56	40	48	36.0	—

*Compare with first subsequent unknown.

†Of course there is no assurance that insects pollinated the blossoms.

relation of weather to the setting of fruit. Under such conditions, provision for cross-pollination is particularly important. Of course, in the Spring of 1928 in parts of western New York neither the provision of good pollen varieties nor bringing bees into the orchard would have solved the problem as bees did not fly during the time that the blossoms were receptive. Under such conditions wind might be expected to distribute pollen from one variety to another if the rows were favorably arranged, but there is little data to show that it actually does so.

The value of having bees and good pollen varieties in the orchard is that in some seasons when there are only a few hours in which bees can fly, satisfactory cross-pollination will be effected whereas it would not have been accomplished if sources of good pollen and abundant insects were not close at hand. It is for such minimum conditions for cross-pollination that the grower should provide. It is also evident that in any region the lack of pollen carriers in the orchard at blooming time may be the limiting factor in the set of fruit and that in order to properly understand the pollination problem a study of the insects of the locality in their relation to pollination is necessary.

Bibliography

1. Chandler, W. H., Fruit Growing. Houghton, Mifflin Co. 1925.
2. Heinicke, A. J. Factors influencing the abscission of flowers and partially developed fruits of the apple. (*Pyrus Malus* L.) N. Y. (Cornell) Agr. Exp. Sta. Bul. 393, 43–112. 1917.
3. ————. Some factors to be considered in the practical application of sterility studies of fruits. Mem. Hort. Soc. of N. Y. 3: 135–138. 1927.
4. ————. The set of apples as affected by some treatments given shortly before and after the flowers open. Proc. Am. Soc. Hort. Sci. 20: 19–25. 1924.
5. Howlett, F. S. Apple pollination studies in Ohio. Ohio Agr. Exp. Bul. 404, 1–84. 1927.
6. ————. Methods of procedure in pollination studies. Proc. Amer. Soc. Hort. Sci. 23: 107–119. 1926.
7. Knowlton, H. E. Methods of experimentation in apple sterility studies. Proc. Amer. Soc. Hort. Sci. 24: 91–93. 1927.
8. MacDaniels, L. H. An evaluation of certain methods used in the study of the pollination requirements of orchard fruits. Mem. Hort. Soc. N. Y. 3: 139–150. 1927.
9. ————. Pollination studies with certain New York State apple varieties. Proc. Amer. Soc. Hort. Sci. 22: 87–96. 1925.
10. Wentworth, S. W., J. R. Furr, and J. L. Mecartney. The spur unit method of determining the comparative effectiveness of different varieties of apple pollen. Proc. Amer. Soc. Hort. Sci. 24: 85–90. 1927.
11. Gourley, J. H. and F. S. Howlett. Ringing applied to the commercial apple orchard. Ohio Agr. Exp. Sta. Bul. 410, 1–24. 1927.
12. Hedrick, U. P. The relation of weather to the setting of fruit; with blooming data for 866 varieties of fruit. N. Y. (Geneva) Agr. Exp. Sta. Bul. 299, 61–138. 1908.

The Behavior of Pollen Tubes in Self and Cross Pollination*

By J. R. Cooper, *University of Arkansas, Fayetteville, Ark.*

THE following is a brief report of some laboratory studies made in connection with a Station project on apple pollination, in an attempt to account for the behavior of different varieties of pollen in direct competition on flowers of the same cluster. Wiggans (2) found that almost invariably fewer sets resulted from selfed than from crossed flowers on all of the varieties tested, and that reciprocal crosses caused definite changes in the relative performance of the different varieties.

Pollen was germinated on different media, and under different conditions of temperature and humidity. Under normal conditions Delicious pollen gave the highest percentage of germination and was the most vigorous, followed closely by Transparent, Ben Davis, Jonathan, and Rome, and with Stayman far behind, due to a high percentage of abortive grains. There was no marked difference in growth of tubes of the different varieties when the grains germinated normally. Variations in temperature and humidity did not materially change the relative performance of different varieties, nor did different media apparently affect one more than another. Decoctions of the stigma or of the whole style did not affect germination in any way, and the use of freshly collected styles with stigmas attached did not seem to affect germination, growth, or direction of growth in any way. In most instances the pollen tubes coming in contact with stigmatic surfaces, especially if at an angle, would turn and grow along the surface of the stigma and in contact with the medium in which it was placed.

Sections of flowers which abscissed early with little or no enlargement showed, for the most part, abundant opportunity for fertilization, in that numerous pollen tubes were found in the locules and invading the ovules, although no embryo growth had taken place. In many instances the egg sack had begun to shrivel and in others had disintegrated. Fruits which abscissed later usually showed definite embryo development, which was accepted as evidence that fertilization had taken place. Dropping continued through what is known as the June-drop stage and on throughout the season of fruit development without any material change in the ratio of abscission from different pollens (1). Some abscission occurred with all pollens both before and after fertilization had taken place, with the selfed flowers leading in every comparison. The abundance of pollen tubes, not only within the locule but often within the ovule, indicated that sterility was not due to failure of the pollen tubes to reach the ovules, and the normal embryos found in later drops is ample evidence that abscission was not always due to sterility.

An attempt was made to determine the relative rate of growth of pollen tubes down the pistils of selfed and crossed flowers. Styles

*Research paper No. 115, Journal Series, University of Arkansas.

were removed for examination 24 and 48 hours after pollination, and some whole pistils were collected at like and shorter intervals. Reciprocal crosses and self-pollinations were made on clusters on the ends of long current growth taken when the blossoms were in the balloon stage and held in water in the greenhouse and in the laboratory. Collections were made every 12 hours after pollination. Some of the material was examined by teasing under the microscope in the fresh state and the remainder held in fixing solution. The most satisfactory method of studying fresh material was to boil for two minutes in N/10 acetic acid after which the outer integument of the pistil with its accompanying hairs could be removed without injury to the internal tissues. Staining was accomplished by using an aqueous solution of lacmoid after first bringing the material to a neutral or slightly alkaline reaction.

The rate of travel of pollen tubes of different varieties through the conductive tissue of the style was not uniform. In the selfed pistils, although there were nearly always a few pollen tubes which seemed to be as vigorous and made as rapid growth as in any of the crosses, the average growth was definitely slower and the number of tubes to reach the locules much smaller than in the crosses. In one lot of Ben Davis pistils collected 24 hours after pollination, the tubes from Delicious pollen averaged the longest followed by Transparent, Jonathan, and Ben Davis. In another lot Delicious pollen led followed by Jonathan, Transparent, and Ben Davis respectively. In a group of Delicious pistils, Ben Davis pollen tubes were the longest, followed by Transparent, Jonathan, Stayman, and Delicious respectively. In Jonathan pistils the Delicious pollen tubes led, followed by Ben Davis and Stayman, with Jonathan making the least growth. In two lots of Stayman pistils Ben Davis led, followed by Transparent and Delicious respectively, with Stayman far behind.

The length of time required for germination of the different varieties of pollen was approximately the same under similar conditions. Many grains germinated whose tubes never entered the stigma. Growth of such tubes soon ceased and the tubes disintegrated. No difference was discernible until the tubes began to force their way down the styles between the cells of the conductive tissue, and the difference was not very noticeable until one-quarter to one-third of the distance had been traversed, when it became apparent that either the growth in the crossed pistils was being accelerated or that it was being retarded in the selfed pistils. Tubes from both Delicious and Transparent pollen have been found in the micropyle of Ben Davis flowers 24 hours after pollination.

At first the course of the pollen tubes is very crooked, the growing points apparently being turned in different directions by the irregular-shaped cells of the conductive tissues lying just below the stigma, but soon they assume a relatively straight course. There are many cases of apparent "discouragement," in which elongation has ceased but growth in diameter continued until the end of the tube becomes almost bulbous. This condition although encountered in crossed as well as selfed flowers was more frequent in the latter. Seemingly

such tubes were unable to force their way longitudinally any farther but the pressure was not sufficiently great to prevent lateral enlargement. Instances have been found of slender continued growth below some such enlargements. The tubes were nearly always smaller in cross section near the base of the style, and in cases where several entered a locule together all became much larger as soon as more space was afforded. As many as six pollen tubes have been found entering a locule in one bundle or group.

No difference in performance could be found after the tubes reached the locule. The general course of travel was down over the placenta and the funiculus to the micropyle, although many instances were noted of tubes wandering over the obturator and to the bottom of the locule, or into the central cavity. Numerous instances were found in the crossed flowers of tubes crossing from one locule to another and some instances of apparent fertilization by such tubes.

The great number of shriveled or abnormal egg sacks in selfed blossoms is an indication, at least, that fertilization did not take place. The high percentage of sets on flowers of the same cluster when a different variety of pollen was used goes to prove that the ovules were not defective. The fact that this same variety of pollen, when used on pistils of another variety, produced a good set would indicate that the fault did not lie in defective pollen.

It would seem that the progress of the pollen tube in the case of self pollination is retarded by some factor or factors, or that the growth of pollen tubes in crosses is accelerated. The latter hypothesis seems the more reasonable. If this is true it must be because they are in some way better equipped to draw upon the conductive tissue through which they pass, for nutriment. The abscission of competing blossoms in the early stages may be due to abortion of the ovules because of deferred fertilization, but later abscissions must be due to conditions arising from or caused by prior fertilization by the more rapidly growing pollen tubes on the crossed flowers between which there is also definite competion.

Bibliography

1. Cooper, J. R. A study of the effect of commercial fertilizers on the performance of apple trees. Ark. Agr. Exp. Sta. Bul. 227. 32–38. 1928.
2. Wiggans, C. B. A suggestion of a safer method for determining the relative value of cross and self-pollination in the apple. Proc. Am. Soc. Hort. Sci. 297. 1926.

The Pollination of the Champlain (Nyack Pippin) and the Lily of Kent Apples

By F. S. LAGASSÉ, *University of Delaware, Newark, Delaware*

THE Champlain (Nyack Pippin) apple altho not largely grown in Delaware has proven itself a profitable variety. The Lily of Kent is an old favorite that still persists in the State, for the reason that it is a good culinary apple and can be held in storage as late as April and May. Studies in 1927 by the author showed the Champlain to be self-sterile and Powell (1) in 1900 showed the Lily of Kent to be self-sterile. Upon the request of growers who were interested in planting large blocks of these varieties, studies were carried on during the 1928 season to determine compatible varieties, for interplanting.

Three trees 20 years old of each variety were used in the studies here reported. They had received cultivation and cover crops and were in a state of good health. As both varieties were known to be self-sterile, emasculations were not made. The common bagging method was used for protecting the blossoms from foreign pollen. The pollen used in the crosses made, was obtained by gathering blossoms in the balloon stage, of the desired varieties. The anthers were scraped from them and placed to dry at room temperature. The dehisced anthers were placed in small bottles and stoppered with vented corks. The pollen was then applied to the bagged blossoms by means of small camel hair brushes, a different brush being used for applying the pollen of each variety. These hand pollinated blossoms were recovered with paper bags which were not removed for several days after application of the pollen.

TABLE I—POLLINATION OF THE CHAMPLAIN (NYACK PIPPIN) APPLE

Variety of Pollen Applied	No. of Flowers Pollinated	% Set May 28, 1928	% Set July 3, 1928
Rome Beauty	121	14.1	11.6
Delicious	324	12.9	8.8
Scarlet Pippin (Crimson Beauty)	153	9.2	8.3
Jonathan	157	8.9	7.7
Yellow Transparent	295	7.5	5.5
Bagged Check* (Brushed)	265	0	0
Normal Set on Trees	1160	4.7	4.0

*"Brushed" indicates that the Champlain pollen was actually brushed upon the stigmas of the blossoms used as checks.

The results obtained are shown in Tables I and II. From Table I it is evident that the Champlain is self-sterile. It is also noted that all of the varieties tested were compatible with Champlain but that Rome Beauty gave the best set. Because of this fact and because Rome Beauty most closely approximates Champlain in time of blossoming, it is recommended that it be used for interplanting with Champlain.

TABLE II—POLLINATION OF THE LILY OF KENT APPLE

Variety of Pollen Used	No. of Flowers Pollinated	% Set May 28, 1928	% Set July 3, 1928
Scarlet Pippin (Crimson Beauty)	397	23.2	14.4
Yellow Transparent	668	19.3	14.8
Delicious	905	13.7	8.0
Grimes Golden	240	9.2	7.5
Jonathan	347	.3	.3
Nero	431	0	*.2
Lily of Kent (Brushed)	367	0	0
Lily of Kent (Unbrushed)	288	.4	0
Normal Set on Trees	1864	6.2	4.7

*The fruit which makes up this percentage was apparently missed in the counts made May 28, 1928.

It is apparent from Table II that the Lily of Kent is self-sterile, and that actually brushing the Lily of Kent pollen onto the stigmatic surfaces did not increase the set of fruit. It is noted that Jonathan and Nero should not be used for interplanting with the Lily of Kent but that several good commercial varieties were found which are compatible. As there is some objection to planting an early variety such as Transparent with the late maturing variety Lily of Kent, it is recommended that Delicious or Grimes Golden be used for interplanting.

In conclusion, the Champlain (Nyack Pippin) and Lily of Kent varieties of apples have been found to be self-sterile in Delaware. Actual brushing of the pollen upon the stigmatic surfaces did not increase the set of fruit in the case of the Lily of Kent. Of several varieties tested Rome Beauty is recommended for interplanting with the Champlain (Nyack Pippin) and Delicious or Grimes Golden with the Lily of Kent.

LITERATURE CITED

1. POWELL, G. H. Kieffer pear pollination and the pollination of apples. Del. Agr. Exp. Sta. 12th Ann. Rept., 129 and 134. 1900.

Fruit Setting in the Delicious Apple

By FREEMAN S. HOWLET, *Experiment Station, Wooster, Ohio.*

THAT the Delicious apple under certain growth conditions tends to be a relatively light yielding variety is gradually becoming recognized. Economic surveys conducted in Michigan and Maine, and one now published in New York have presented some definite comparisons. That the light yields are due in part to light fruit setting rather than entirely to irregular and light fruit bud formation has also become evident. In Ohio, Delicious shows a tendency to set light, even in mixed plantings.

The purpose of the present study of which this is only a preliminary report, is to evaluate the factors responsible for the light setting. The first factor considered in its influence on set is the importance of competition for nutritive materials among the flowers and partially developed fruits. In order to measure the extent of this competition, deflorations previous to full bloom were made to ascertain the relationship of the number and position of the flowers on the cluster base to the set thereon.

EFFECT OF COMPETITION AMONG FLOWERS AND FRUITS

In 1927, in accordance with this procedure, a considerable number of clusters on a vigorous 35-year-old tree growing in grass mulch in the Station orchards, were partially deflorated. The tree is fertilized annually with sodium nitrate and receives a moderate dormant pruning. The clusters were partially deflorated just as the petals of the lateral flowers were unfolding. The various combinations of flowers left are shown in Table I. After hand pollination with viable Jonathan pollen, the flowers were allowed to be open pollinated. They showed no frost injury. Weather conditions during blooming and fruit setting in 1927 were favorable.

TABLE I—RELATION OF POSITION AND NUMBER OF FLOWERS TO ABSCISSION AT THE FIRST DROP. DELICIOUS, 1927

Flowers Left per Cluster	Number of Clusters	Percentage Set of Flowers	Percentage Set: Terminal Flowers	Percentage Set: Lateral Flowers
Terminal flower	86	54.6	54.6	
One lateral flower	81	48.1		48.1
Terminal and one lateral	53	20.8	39.6	1.9
Two lateral flowers	91	12.1		12.1
Terminal and two laterals	73	11.9	31.5	2.1
Three lateral flowers	83	7.2		7.2
Open pollinated Entire cluster	254	3.2	7.5	2.1

The data presented in Table I show that, while one flower alone, whether terminal or lateral, set 48 to 55 per cent there was a marked decrease in percentage set—the larger number of flowers left to a cluster. Moreover, the presence of the terminal flower on a cluster with laterals, depressed the set of the laterals.

In 1928 two partial deflorations were made on a top-worked, rather heavily pruned tree in the same orchard. The first defloration was made as soon as the individual flowers of the cluster could be separated sufficiently for removal (April 30). The terminal flowers which were beginning to turn pink were eliminated because of the rather large number which showed abortion. The second defloration and the cross pollination of the flowers left at both deflorations was made just as the petals of the lateral flowers were unfolding (May 12). After hand pollination with viable Grimes Golden pollen, the flowers were left to open pollination. The lateral flowers were not frost injured and weather conditions during blooming and fruit setting were favorable.

The writer expected that the percentage set of the flowers left at the first defloration would be considerably higher than that of the corresponding number of flowers left at the second defloration, 13 days later, provided the supply of nutritive materials during this period was the principal limiting factor. The results, as shown in Table II were not in accordance with this expectation. A comparison

TABLE II—RELATION OF NUMBER OF LATERAL FLOWERS TO ABSCISSION AT FIRST AND SECOND DROPS. DELICIOUS, 1928

Flowers Left per Cluster	Number of Clusters	Percentage of Clusters with			Percentage Set of Flowers
		0 Fruits	1 Fruit	2 Fruits	
		After 1st Drop			
One lateral					
1st defloration....	42	69.0	30.7		30.7
2nd defloration...	89	57.3	42.7		42.7
Two laterals					
1st defloration....	32	68.7	25.0	6.3	21.8
2nd defloration...	92	47.8	45.7	6.5	29.3
Three laterals					
1st defloration....	31	43.9	56.1		18.3
2nd defloration...	87	55.2	39.1	5.7	16.9
Four laterals					
1st defloration....	29	37.9	37.9	24.2	21.6
2nd defloration...	75	56.0	30.6	13.4	14.4
		After 2nd Drop			
One lateral					
1st defloration....	42	69.0	30.7		30.7
2nd defloration...	89	65.2	34.8		34.8
Two laterals					
1st defloration....	32	68.7	25.0	6.3	21.8
2nd defloration...	92	50.0	44.5	5.4	27.7
Three laterals					
1st defloration....	31	43.9	56.1		18.3
2nd deflora ion...	87	59.8	36.8	3.4	14.5
Four laterals					
1st defloration....	29	41.4	44.8	13.8	18.1
2nd defloration...	75	61.4	29.3	9.3	12.0

of the percentage sets after the two treatments indicates that other factors complicated the results. Stronger, more vigorous flowers were unavoidably chosen at the second defloration than at the first because of the small size of the flowers at the earlier defloration.

Moreover, it is probable that greater competition between flowers of the cluster occurred during full bloom and the few days thereafter than during the period of flower enlargement. Confirmation of this very keen competition among fully developed flowers has been obtained in some pollination investigations. Partial defloration of open-pollinated clusters to 2 flowers during the early part of full bloom, usually doubled the set of flowers as compared with complete clusters.

Table II also shows that the set of lateral flowers materially decreased only up to 3 flowers when 3 and 4 flowers remained. It is to be noted that the percentage set of both 3 and 4 flowers is similar to that usually found in open-pollinated complete clusters.

Relation to Open-Pollinated Flowers

In 1927 and 1928 counts were made on several limbs on each of a number of vigorous open-pollinated trees to determine percentage of flowering clusters setting fruit, as well as the number and location of the fruits on each fruit-bearing cluster. Table III presents the results from 7 of these trees which were not frost injured and which were exceptionally well cross-pollinated. It might be expected in view of the depressing effect of the terminal flower on the set of laterals, as indicated in Table I, that the greater proportion of the fruits remaining would be terminal in position. However, as shown in Table III, the percentage set of the terminal flowers is low and even may be less than that of the laterals. It was found that on considering all trees 55 to 93 per cent of the fruits were lateral in position. Therefore, it appears that the depressing effect of the terminal is modified by and is co-existent with another factor of considerable importance.

TABLE III—Percentage Set of Open Pollinated Flowers After First Drop. Delicious, 1927 and 1928

Number and Culture of Trees	Total Number of Flowering Clusters	Percentage of Clusters Fruiting	Percentage Set		
			Terminal Flowers	Lateral Flowers	Entire Cluster
1927					
1 Cultivation, no nitrogen	454	73.8	16.8	14.2	14.7
3 Cultivation, nitrogen....	1427	72.3	20.7	12.4	13.9
1 Straw mulch, no nitrogen	413	74.6	23.5	12.5	14.6
1 Straw mulch, nitrogen ..	459	78.2	15.7	17.2	16.9
1928					
1 Cultivation...........	385	75.8	8.6	26.8	23.5

Normal Drops in Delicious

To aid in an understanding of the problem of fruit setting of Delicious, the normal drops of flowers and partially developed fruits must be pointed out. Figure 1 is charted from the daily drop in 1928

of 13-year-old vigorous tree, whose petals fell on May 20. There was a very heavy first drop made up largely of flowers which had not increased in size subsequent to petal fall, followed by a light second drop of partially developed fruits. That the heavy first drop of this tree is normal is also shown by the percentage sets ranging from 14 to 24 for the open-pollinated trees whose data are presented in Table III.

There are three distinct characteristics of this first drop. It removes all fruits from a large number of clusters; moreover, there tends to be considerable irregularity on the same tree in the proportion of fruiting to flowering clusters. Finally nearly all the fruit bearing clusters possess only 1 or 2 fruits. It is obvious that this is in marked contrast to such heavy setting varieties as Jonathan and Grimes Golden which usually have 3 to 5 fruits to the cluster after

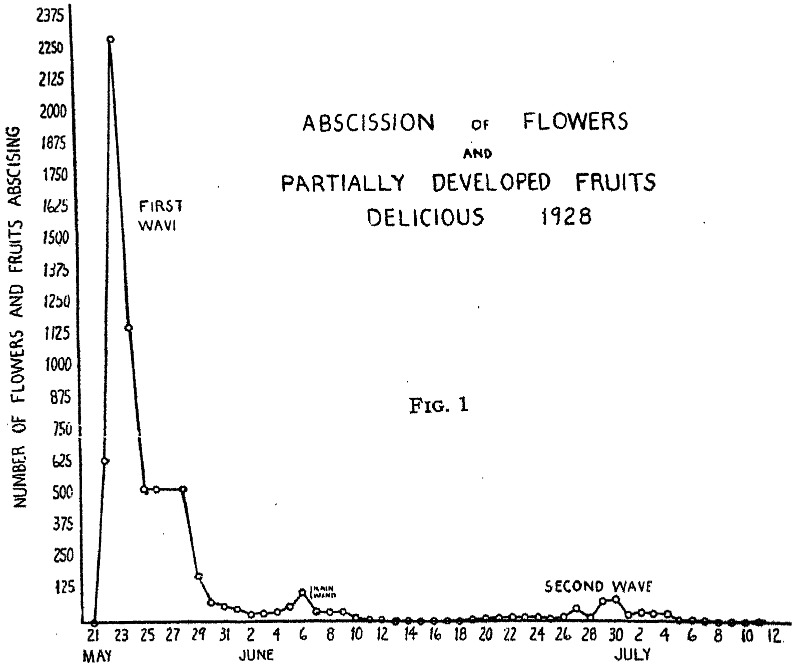


FIG. 1

the first wave of dropping is completed. As might be expected following this heavy first drop in Delicious the second drop is normally light or negligible. Additional data, confirming the normality of the second drop, as shown in Fig. 1, is found in Table II for the hand-pollinated flowers. The percentages of the flowers setting fruit after the second drop were only slightly lower than those for the first.

It should now be clear that the problem in Delicious entails the consideration of the factors which are responsible for the severity of the first drop as compared with that of such varieties as Jonathan and Grimes. From a practical viewpoint the question involved is the effect of cultural practices in increasing the fruit-bearing clusters, the regularity of setting, as well as the number of fruits to a cluster.

Effect of Vigor on Fruit Setting

It is to be recalled that the trees whose data are presented in this paper, are receiving a moderate dormant pruning and annual fertilization with nitrogen. These are fully as vigorous as those found in the best commercial orchards. The problem is not one of the effect of such vigor-producing practices as pruning and fertilization on devitalized trees. It does concern the effect of heavy pruning and moderate fertilization on the severity and irregularity of the first drop from trees of already good commercial vigor.

The writer has observed that the highest percentage of fruit-bearing clusters as well as the greatest number of fruits per cluster have been obtained in locations on the trees where the vigor is the greatest. Only in the very tops of heavily pruned Delicious trees have there been found an appreciable number of clusters surviving the first drop with 3 to 4 fruits.

The defloration experiments as well as the results from heavy pruning and moderate fertilization have indicated that the maintenance of exceptional vigor is particularly desirable if fruit setting in Delicious is to be kept at the highest possible level. The writer concurs with Chandler (1) in the beneficial effect of pruning upon light setting varieties of apples.

Effect of Pollen Upon Fruit Setting

The conclusions from this study do not deny that considerable of the light fruit setting of Delicious is due to inadequate pollination. Unquestionably the variety has been and is still being grown in locations where pollination is inadequate. The data obtained do, however, give increased emphasis to the necessity for adequate cross pollination by the good pollinizers pointed out by Whitehouse and Auchter (5). However, even with adequate cross pollination this variety as well as Stayman, Arkansas, and Winesap, fail to give the high sets obtained with such heavy setting varieties as Jonathan, Grimes, Baldwin, Wealthy, and Yellow Transparent.

It is to be noted that the trees used have been abundantly cross pollinated. They are either in the midst of or within a few yards of the large Station variety orchard in which are always a considerable number of hives of bees. Ranker (4) in Utah stated that Delicious under normal conditions, that is, even with adequate pollination, thins its flowers to a maximum usually of 1 fruit to a spur. The relatively light fruit setting of Delicious even with adequate pollination is also indicated by the pollination experiments reported by Haber (3) and Dorsey (2). They obtained low percentage sets with a considerable number of pollinizers. Although Delicious is unquestionably sensitive to pollination procedure yet the percentage sets of Delicious in the Whitehouse and Auchter experiments with good pollinizers, while fully sufficient for a commercial crop, were similar to those reported in this paper.

Effect of Other Factors

In view of the previous discussion, it now seems probable that there is at least another factor in addition to inadequate vigor and pollination which is in part responsible for the light fruit setting of Delicious. It is very likely that this factor, if present, is inherent in the variety, and has its cytological expression in abnormalities of the sex elements.

The first step has been to ascertain by microscopic examination whether or not the ovules of the falling flowers and partially developed fruits from open- and hand-pollinated clusters of vigorous trees have been fertilized. This examination has indicated that fertilization has probably not occurred in a very large proportion of the ovules of the unenlarged flowers abscising very shortly after petal fall. The enlarged, partially developed fruits of the first and second drops show various stages of embryo development in nearly all ovules. It is thus probable that whatever abnormalities occur in the sex elements result not only in failure of fertilization but also in embryo abortion. The final step, in the study, has been the examination of the meiotic divisions and subsequent processes leading up to the formation of the embryo sac nuclei. Are there abnormalities in chromosome behavior which can account for failure of fertilization and embryo abortion? In view of the fact that the examination of the meiotic divisions is only in its early stages the results cannot be presented in this paper.

Literature Cited

1. Chandler, W. H. Fruit growing. Houghton-Miflin Co. 1925.
2. Dorsey, M. J. The set of fruit in apple crosses. Proc. Amer. Soc. Hort. Sci. 82–94. 1921.
3. Haber, E. S. Pollination Studies with Jonathan and Delicious Apples. Rept. Iowa State Hort. Soc., 58:154–56. 1923.
4. Ranker, E. R. Some physiological considerations of the "Delicious" apple with special reference to the problem of alternate bearing. Amer. Jour. Bot., 13:406–426. 1926.
5. Whitehouse, W. E., and Auchter, E. C. Cross pollination studies with the Delicious apple. Proc. Amer. Soc. Hort. Sci., 23:157–161. 1926.

Relative Effectiveness of Apple Pollen from Vigorous and Weak Trees as Determined by the Spur-Unit Method

By S. W. Wentworth, *Cornell University, Ithaca, N. Y.*

During the past nine years the spur-unit method (1) of investigating pollination problems has been in use in the Cornell orchards under the direction of Dr. A. J. Heinicke. With this method, the various pollens which are being tested are all placed on the flowers of each spur. If a sufficiently large number of spurs are used to overcome the slight variability which may exist among the lateral flowers of the spurs, it is obvious that compensation has been made for all variables except the one which is to be measured, namely, the variability of the pollens used. The method, therefore, appears to be well adapted to measuring slight differences in pollens such as might be expected to exist among samples of pollen of the same variety which have been produced under different conditions of vigor, or in different sections of the country, or even on flowers of different sizes or positions on the spurs.

That apple pollen does vary within the variety depending upon the physiological conditions under which it was produced, has been suggested by Auchter (2) and Sandsten (3). The probability that pollen may vary depending upon the locality where produced is suggested by a comparison of the results of germination tests by various investigators. Thus, the highest germination for Baldwin pollen obtained by Howlett (4) was 7.5 per cent; by MacDaniels (5), 13 per cent; and by Overholser (6), 25 per cent. In the case of Rhode Island Greening pollen, Howlett (4) reports an average germination of 7.5 per cent; MacDaniels (5), 13 per cent; and Overholser (6), about 42 per cent. However, Kvaale (7) seems to think that apple pollen of a single variety, whether produced in different countries or in different years, does not show significant differences in its germinability. Since many investigators have obtained their pollen from a single tree or have made little mention of the source of the pollen or the conditions under which it was produced, it appears that the possibility of pollen varying within the variety is not taken seriously by most workers.

Procedure

Pollen was obtained from four Rhode Island Greening trees differing markedly with respect to vigor. Tree AH 2 was very weak. The 1927 terminal growth was about three inches and the 1928 growth was less than one inch. During both seasons the leaves were light green in color. Tree AG 2 made a twig growth of nine inches in 1927 and eight inches in 1928. The leaves were sparse, below average in size, and light green during both seasons. Tree AH 10 was considerably more vigorous than the two preceding trees. It had an average twig growth of 15 inches in 1927 and 30 inches in 1928. The leaves during both seasons were dense, above average in size and dark green in color. These three trees are 17 years old and

are maintained under clean cultivation and cover crops. The fourth tree, growing in the Kimball orchard, has been consistently vigorous and heavy bearing. It has clean cultivation on one side and sod on the other. It has made an annual twig growth of 15 to 20 inches. This tree is 25 years old. There was no bloom on any of the trees in 1927, but in 1928 all trees bloomed heavily.

Pollen was also obtained from two weak Delicious trees, ND 14 and ND 4, and two vigorous Delicious trees, ND 6 and ND 16. All four of these trees were growing under clean cultivation and cover crops. The two weak trees made less than four inches of terminal growth in 1927 and practically no growth in 1928. The two vigorous trees each made 12 to 15 inches growth in both 1927 and 1928. The foliage on the weak trees was light green to yellowish and on the vigorous trees dark green during both years. All trees had a light to medium bloom in 1927 and a medium to heavy bloom in 1928.

Ten vigorous 12-year-old McIntosh trees, selected for uniformity from a large block maintained under clean cultivation and cover crops in the Cornell orchards, were used as female parents. During the bloom period, May 15 to 21, there were 44 hours of sunshine. The maximum daily temperatures for the period ranged from 69° F. to 83° F. and the minimum temperatures for the period varied from 30° F. to 59° F. On three days the temperature rose to above 80° F. a fact which accounts for the short duration of the bloom period.

The technique used in selecting vigorous spurs, thinning the flowers to four laterals, bagging with "Glassine" paper bags, gathering, maturing, and applying the pollen was essentially the same as described in a previous paper (1). In the present investigation, 30 vigorous spurs were selected on each of the 10 trees. Ten spurs on each tree (Series A) were pollinated in the following manner: One flower of each spur received pollen from AH 2, another flower received pollen from AG 2, a third flower received pollen from AH 10, and a fourth flower received pollen from the Kimball Rhode Island tree. Thus, the four Rhode Island pollens from different trees were allowed to compete on the same spurs.

In a second series (Series B) consisting of 10 spurs on each tree, the pollens from the four Delicious trees were allowed to compete in a similar manner. In a third series (Series C) consisting of 10 spurs on each tree, pollen from two weak Delicious trees was allowed to compete with pollen from one vigorous and one weak Rhode Island tree. The three series, consisting of 100 spurs each, were all pollinated on May 20.

Presentation of Results

Pollen from Weak versus Vigorous Rhode Island Trees. The data presented in Table I clearly show that pollen obtained from different Rhode Island trees varied considerably in its ability to set fruits on McIntosh trees. Pollen from the vigorous tree in the Kimball orchard was considerably more effective than that obtained from the other trees. Tree AH 10 was fully as vigorous as the Kimball Rhode Island and yet the pollen from this tree was very ineffective. It is therefore impossible from this data to correlate directly the potency of the Rhode Island pollen with the vigor of the tree.

TABLE I—EFFECT OF VIGOR OF POLLEN PARENT ON SET OF MCINTOSH FRUITS

Series A—Rhode Island Pollen

McIntosh Trees ♀ Parents	Per cent Set from Each Pollen June 6, 1928			
	R. I. (A. H. 2) Weak	R. I. (A. G. 2) Weak	R. I. (A. H. 10) Vigorous	R. I. (Kimball's) Vigorous
K. G. 1	10	10	00	40
K. G. 3	00	20	00	40
K. G. 10	00	00	10	40
K. G. 13	*00	*00	*00	*33.3
K. G. 17	00	10	00	90
K. G. 19	10	10	00	30
K. H. 18	00	10	00	30
K. H. 15	00	00	00	30
K. H. 12	00	00	00	30
K. H. 10	00	10	10	*33.3
Av. % Set	2.0	7.1	2.0	39.9±3.9
No. Mature Fts.	1	2	—	30.0
Av. Wt. Fts. (gm.)	—	—	—	130.0±3.7
Av. No. Mature Seeds	—	—	—	6.2±0.30

Series B—Delicious Pollen

McIntosh Trees ♀ Parents	Per cent Set From Each Pollen June 6, 1928			
	Del. (N. D. 14) Weak	Del. (N. D. 4) Weak	Del. (N. D. 6) Vigorous	Del. (N. D. 16) Vigorous
K. G. 1	90	70	80	90
K. G. 3	60	70	50	70
K. G. 10	*66.7	*66.7	*55.6	*55.6
K. G. 13	20	00	30	10
K. G. 17	*33.3	*22.2	*55.6	*55.6
K. G. 19	20	00	10	20
K. H. 18	*33.3	*44.4	*44.4	*44.4
K. H. 15	*22.2	20	20	*33.3
K. H. 12	10	00	20	10
K. H. 10	10	10	30	20
Av. % Set	36.5±5.7	29.9±6.4	39.2±4.6	40.6±5.8
No. Mature Fts.	16	15	19	26
Av. Wt. Fts. (gm.)	116.4±4.1	119.9±4.0	127.9±3.3	129.0±3.7
Av. No. Seeds	7.2±0.42	7.1±0.36	8.4±0.28	8.2±0.3

Series C—Delicious versus Rhode Island Pollen

McIntosh Trees ♀ Parents	Per cent Set from Each Pollen June 6, 1928			
	(Del. N. D. 14) Weak	Del. (N. D. 4) Weak	R. I. (A. G. 2) Weak	R. I. (A. H. 10) Vigorous
K. G. 1	60	60	10	00
K. G. 3	70	80	10	00
K. G. 10	80	90	00	00
K. G. 13	*55.6	*55.6	*00	*00
K. G. 17	*66.7	*77.8	*00	*00
K. G. 19	*66.7	*44.4	*00	*00
K. H. 18	*22.2	20	00	10
K. H. 15	10	40	00	00
K. H. 12	10	20	00	20
K. H. 10	*55.5	50	00	00
Av. % Set	49.5±5.5	53.6±5.1	2.1	3.1
No. Mature Fts.	38	39	2	2
Av. Wt. Fts. (gm.)	131.1±2.8	131.2±3.2	—	—
Av. No. Seeds	7.4±0.35	7.3±0.32	—	—

*Nine flowers pollinated instead of 10.

Comparison of 1927 and 1928 Rhode Island Pollen. In the 1927 work on the spur-unit method (1) the Rhode Island pollen, although competing with pollen from Delicious, Baldwin, and McIntosh trees, gave an average set of 36.7 per cent. In this case the pollen was a composite sample taken from several Rhode Island trees. In 1928, where there was no competition by other varieties of pollen, the average set from the best two Rhode Island pollens was about 23 per cent. This decrease in the percentage set was apparently due to a decrease in the potency of the pollen or to a decrease in the ability of the McIntosh trees to set fruits.

Pollen from Weak versus Vigorous Delicious Trees. It is apparent from the data in Series B that Delicious pollen, although obtained from extremely weak trees, may be very effective in pollinizing McIntosh flowers. A statistical analysis of the figures indicates that there was slight if any difference in the pollen from the weak and vigorous trees. Thus, if Student's method is used, and if the percentages set obtained with pollen from the weak trees are paired with those obtained with pollen from the vigorous trees, it is found that the odds are only seven to one that the difference in favor of the vigorous trees is significant. However, it is of interest to point out that the number and average weight of mature fruits and the average number of mature seeds in the fruits are also in favor of the pollen from the vigorous trees.

Pollen from Delicious versus Rhode Island Trees. In series C, pollen from the weak Delicious trees competed with pollen from one weak and one vigorous Rhode Island tree. Evidently the flowers pollinated with Rhode Island pollen offered little competition for those pollinated with Delicious. It is interesting to note that the pollen from the two weak Delicious trees set 77 mature fruits where it competed with Rhode Island pollen (Series C) whereas, it set 31 mature fruits where it competed with pollen from the two vigorous Delicious trees (Series B). This difference is due to the greater competition among the fruits where all four flowers of the spurs were pollinated with Delicious.

In view of the foregoing discussion, it appears that the true difference in the pollen from the weak and vigorous Delicious trees (Series B) may not have manifested itself because of the competition among fertilized flowers or the inability of the spurs to hold more fruits.

Variation in Female Parents (McIntosh Trees). The data contained in series B show a rather wide variation in the capacity of the McIntosh trees to set fruits. Thus the set from all four of the pollens is relatively low on KG 13, KG 19, and KH 12, and relatively high on KG 1, KG 3, and KG 10. This variation in the set on different trees resulted even though all of the trees were selected for their uniformity in the amount of bloom, size, age, and general vigor of the trees. Similar variation among McIntosh trees was found in previous work on the spur-unit method (1). This emphasizes the importance of using several trees in a pollination experiment.

The author wishes to express his appreciation to Dr. A. J. Heinicke, under whose direction this work was carried on, and to Dr. L. H.

MacDaniels for valuable suggestions during the course of the investigation.

LITERATURE CITED

1. WENTWORTH, S. W., FURR, J. R., and MECARTNEY, J. L. The spur-unit method of determining the comparative effectiveness of different varieties of apple pollen. Proc. Amer. Soc. Hort. Sci., 24:85–90. 1927.
2. AUCHTER, E. C. Apple pollen and pollination studies in Maryland. Proc. Amer. Soc. Hort. Sci., 18:51–80. 1921.
3. SANDSTEN, E. P. Some conditions which influence the germination and fertility of pollen. Wis. Agr. Exp. Sta. Res. Bul. 4. 1909.
4. HOWLETT, F. S. Apple pollination studies in Ohio. Ohio Agr. Exp. Sta. Bul. 404. 1–84. 1927.
5. MACDANIELS, L. H. Pollination studies with certain New York State apple varieties. Proc. Amer. Soc. Hort. Sci., 22:87–96. 1925.
6. OVERHOLSER, E. L. Apple pollination studies in California. Cal. Agr. Exp. Sta. Bul. 426. 1–17. 1927.
7. KVAALE, ERLING. Abortive and sterile apple pollen. Memoirs of the Hort. Soc. of New York, 3:399–408. 1927.

The Effects of Nitrogen on the Set of Apple Flowers Situated Variously on the Cluster Base

L. R. DETJEN, *Experiment Station, Newark, Delaware.*

THE effects of nitrogen on the relative set of apple flowers situated variously on the cluster base when considered in relation to unfavorable weather conditions at blooming time seems worthy of consideration. It (1) has been said that in the Winesap family the lateral flowers on the cluster base have an unequal chance of setting with those situated centrally but that in some other varieties the chances are more nearly equal. Observations in the summer of 1928, after spring frosts had killed and injured many central flowers on Stayman trees, revealed the following situation regarding set of fruits in reference to position on the cluster base. In the top of one tree 74 per cent of the fruits were centrals and 26 per cent were laterals; in the top of another tree there were 25 per cent centrals and 75 per cent were lateral fruits. On the lower branches of two other similar trees the following observations were recorded: 35 per cent and 58 per cent respectively for the central, and 65 per cent and 42 per cent for the lateral fruits. All of this emphasizes the ability of flowers situated laterally on the cluster base even in the Winesap group to contribute materially under certain conditions to the general crop yield. All previously conducted experiments by other investigators take the view of central vs. lateral flowers and make no distinction regarding the various positions that a flower might occupy on the cluster base. The following evidence is presented to throw further light on the performance of flowers when situated variously on the cluster base and their reaction to nitrogenous fertilizers.

As is well known the Stayman variety of apple generally bears one fruit to the spur. It was, therefore, considered ideal for experiments in the setting of fruit in relation to the position of flowers on the cluster base. The trees that were chosen for observations were such

as had been definitely treated with or without nitrogen for over a period of eighteen to twenty years. The experiment, therefore, is not based on the immediate effects of nitrogen on the set, but rather, on the cumulative effects over a period of years.

In 1926 two trees, 48–15 and 48–17, were chosen, mainly because they were of good size for their age, of good health, and carried many fruit buds. They had received fair all-around treatment but without regularity. Both trees later proved to have been in the "on-year." In 1927 very little good Stayman material was available in the orchard because of the general "off-year" for the variety. This fact necessitated the use of four trees, instead of two, to provide the necessary number of spurs. The four trees, however, were not similar to each other and this fact necessitates further explanations. Two of the trees, 38–29 and 38–35, had received from the beginning, among other things, an annual application of about three pounds of sodium nitrate each. The trees were healthy and made good growth. This season each produced relatively few flowers and were in a typical "off-year." The other two trees, 38–43 and 40–43, had never received any applications of fertilizers and were this year quite different from each other in appearance and performance. Tree 38–43 had borne a good crop of fruit the previous year; yet this year it was so loaded with flower-bearing spurs that it looked like a typical "on-year" tree. The terminal growth was short, and both flowers and foliage later indicated a shortage of available nitrogen. Very little fruit was harvested. On the other hand tree 40–43 was more robust, healthy, and fairly vigorous. The relatively few flowers clearly indicated a typical "off-year" tree. It compared favorably in these respects with trees 38–29 and 38–35.

In 1928 two other trees, 46–35 and 46–37, were chosen because their condition indicated good, healthy vigor and a good crop of flower-bearing spurs. Each tree had received annually from the beginning about six pounds of sodium nitrate. Both trees appeared similar in all respects.

The data collected covers a period of three years, from 1926 to 1928 inclusive. In 1926 seven hundred spurs were selected, each bearing six apparently perfect flower buds, and situated on wood, three years of age or more. They were selected for a length ranging between one-half and one inch, and a diameter of about one-quarter inch. In later years, because of insufficient material, spurs of various lengths were chosen and only five- instead of six-budded clusters were selected. One hundred labels were used to mark spurs that were not to be deflorated. These were to serve as checks on those that were treated. The remaining six hundred labels were divided into six equal lots and each lot marked with numbers, from one to six, denoting the respective positions of flowers on the cluster base. Label marked "1" denotes the central flower, label "2" denotes the second flower from the top or the first lateral, and the other labels were similarly marked going down the scale on the cluster base. In 1927 and 1928 when only five-budded spurs were selected the number "6" or fifth lateral was simply omitted from the sets of labels.

TABLE I—THE EFFECTS OF NITROGEN ON THE SET OF APPLE FLOWERS WHEN SITUATED VARIOUSLY ON THE CLUSTER BASE

Tree No.	38–43	40–43	48–15	48–17	38–29	38–35	46–35	46–37
Nitrogen Treatment	No N. for 19 Years	No N. for 19 Years	Irregular Applications 18 Years	Irregular Applications 18 Years	3 lbs. $NaNO_3$ Annually 19 Years	3 lbs. $NaNO_3$ Annually 19 Years	6 lbs. $NaNO_3$ Annually 20 Years	6 lbs. $NaNO_3$ Annually 20 Years
Vigor........	Little growth	Fair growth	Fair growth	Fair growth	Good growth	Good growth	Good growth	Good growth
"Off" or "On" year..	On	Off	On	On	Off	Off	On	On
Year........	1927	1927	1926	1926	1927	1927	1928	1928
Position	Set in Terms of Per cent							
*0	18.8	66.6	16.0	28.0	72.7	80.0	22.7	33.3
1	11.8	26.6	42.0	50.0	20.0	12.5	28.7	34.3
2	5.4	6.6	16.3	32.6	55.0	55.5	20.8	40.6
3	5.4	17.6	22.0	21.7	41.6	60.0	24.2	41.3
4	5.5	20.0	29.1	32.4	42.8	50.0	52.2	53.1
5	5.4	15.3	22.4	24.4	47.6	55.5	56.7	69.6
6			12.8	22.9				

*"0" denotes non-deflorated clusters, "1" denotes apical flowers only, "2" deotes first or highest lateral only, "3" denotes second lateral, etc.

The partial defloration of spurs consisted simply of pinching off four of the five flower buds. All buds, therefore, except the ones designated by the respective labels were removed. The sets of labels were shuffled in some years and in others they were applied alternately to avoid any selective tendency.

In 1926 and 1927 insect cross-pollination was relied upon entirely, and the results secured seemed perfectly satisfactory. In order to insure thorough pollination however, hand pollination was performed in 1928. The final count in 1926 was made in October at time of harvest, while in 1927 and 1928 the counts were made on June 27 and 26 respectively, which is well after the June drop.

In order to present the data in as compact a form as possible it is given in tabular form, from which comparative data can be viewed at a glance.

Discussion of Results

An analysis of the data seems to lend emphasis to the following points:

(1) As the application of nitrogen increases the per cent set for all flowers increases. It is true that trees 38–29 and 38–35 did set an even higher per cent than those that received more nitrate but here the per cent set is visibly affected by the "off-year" factor and its attendant small total numbers of flowers. The same explanation may be offered in regard to the record of tree 40–43 in 1927 as against that of 38–43 in the same non-nitrated block. These three trees are the only ones that recorded a relatively high per cent set and all three were in a typical "off-year."

(2) In the "on-year," with the exception of 38–43, which was not typical, as previously stated, the records show that the per cent set of the undeflorated spurs is relatively lower than that of those spurs that were treated notwithstanding the fact that five and six times as many flowers were represented. Indeed, it seems that because of the larger numbers of flowers competing for food on the same cluster base the per cent set would necessarily have to fall if only one matured fruit to the spur is the rule as it appears to be with Stayman. In the "off-year," however, these figures are reversed, the undeflorated spurs giving a much higher per cent set. This increase in per cent set clearly seems to be due to the set of laterals either with or without a central fruit. The reason for this reversal of performance probably lies in the reduced total number of flowering spurs and the comparatively greater nitrogen reserve in the trees available for the full set of flowers.

(3) From comparative records of different trees in different years, it seems that in the "on-year" the per cent set of flowers on undeflorated spurs is considerably less than in the "off-year." This can be explained by the comparatively greater reserve of food materials at the command of the smaller number of spurs blossoming in the "off-year."

(4) The central flower on the cluster base, being better constituted and better situated, generally gives a higher per cent set over

the laterals. This of course must bar any mishap to such flowers as took place through frost and cold in 1928 with the Stayman variety. Of course all flowers that showed discoloration of the pistils or stigmatic tissue in this experiment were quickly rejected yet many apparently uninjured flowers seem to have suffered severely from chilling alone so that the per cent set was materially reduced. Whether the central flowers of 1927 on the well fed trees were similarly killed is not known, the records strongly so indicate. The increased set of central over lateral flowers is best indicated on trees not well supplied with nitrogen.

(5) Flower No. 2 on the cluster base, which is the first lateral, appears slightly less able to set a fruit than the laterals lower on the cluster base.

(6) In well nourished trees, barring accidents, the lower flowers on the cluster base have an equal or slightly better chance for fruit setting than those immediately above except the central flower.

The last two points seem very similar in regard to cause and effect and may be explained on this theory: In all apple flower clusters there are leaves or leafy structures at the base of the individual flowers, which average largest for the lowest, and smallest for the highest situated flower. Flower No. 2 is seldom supplied with a leaf, sometimes in varieties like Transparent and Jonathan even Flower No. 3 may bear no leafy structure. The other flowers bear bracts or leaves that grow larger in size as the scale on the cluster base descends. With these facts in mind it seems quite possible to picture the results. The central flower because of its more favorable position and early start usually sets. Flower No. 2, however, being situated laterally and not having the support of a growing leaf, has much less chance to set and develop unless the cluster base is well supplied with nitrogen and other plant foods. On the other hand, the lowest flowers on the cluster base are supported by the largest leaves, which help sustain their respective flowers through the trying times of fruit setting. Again, observations made in 1928 give such indication. The total number of fruits obtained from the 100 undeflorated clusters were 26, of which 14 were central, 7 were laterals of position 4, and 5 were laterals of position 5. No fruits in this count were obtained from positions 2 and 3 on the cluster base. From these results it might also be inferred that any injury to the subtending leaves, for instance that occurring from injurious spray material, might have a direct bearing on the set of any particular flower on the cluster base, especially if a supply of available nitrogen is lacking.

Literature Cited

1. Howlett, F. S. Some factors of importance in fruit setting studies with apple varieties. Proc. Am. Soc. Hort. Sci., 307–315. 1926.

A Preliminary Report upon the Production of Seedling Fruit Stocks

By H. B. Tukey, *Experiment Station, Geneva, N. Y.*

VERY little published information is available upon the production of seedling fruit stocks. Scientific thought has been concerned largely with asexual propagation and with the production of superior stocks upon which to propagate fruit varieties, to the end of greater uniformity in orchard plants. It must be remembered, however, that the fruit trees of America are propagated almost exclusively upon seedling stocks, so that in view of the proposed quarantine against the importation of fruit stocks in 1930, experiments in the domestic production of seedling stocks, though possibly not of great scientific interest, are nevertheless of practical importance.

Nurserymen select two distinct types of roots for propagation purposes, namely, straight roots for use in winter grafting, and branch roots for lining-out and budding. In some sections of the country where apple trees are propagated largely by grafting, the straight-root seedlings are preferred. In New York nursery sections, however, where grafts do not grow rapidly enough to produce saleable trees, recourse is made to budding during the first growing season, and for this purpose the branch-root seedling has proven superior to the straight-root and is the one desired. Unfortunately there has been until recently little attempt in this country to produce branch-root seedlings; seedlings of this type having been imported from Europe.

In the production of seedling stocks during three seasons at the New York State Agricultural Experiment Station at Geneva, New York, three methods have been used, namely, (1) From seed in one season without transplanting, (2) from seed in one season but with transplanting, and (3) by growing for more than one season. The first method is the one commonly employed in the seedling sections of America and gives a high proportion of straight roots. The transplanting method is used largely in the seedling producing sections of Europe. The third method is used in all sections, but to a small degree.

The first problem in all three methods is in the securing, handling, and the storage of seeds. With seeds of the hardy fruits a period of after-ripening is essential, which in these tests has been effected at temperatures of 34 to 41 degrees F. and under moist conditions. Storage in a cool cellar in damp sand, in the ice compartment of a refrigerator, in an ice house, and out-of-doors in prepared beds, have all given good results. Fall planting has accomplished the same results, though because conditions during the dead of winter are not ideal for after-ripening there may be insufficient time to complete after-ripening with such seeds as cherries, unless they are planted early. With pears and apples late planting is satisfactory, so far as after-ripening is concerned, yet for other reasons spring planting is preferred.

The source from which seed is secured is an important factor. Domestic supplies of seed have generally given better germination than those of imported seed. Seed from late ripening varieties of

both sweet and sour cherries has given the higher germination, while early ripening sorts have given few viable seeds. Furthermore, seed from fully ripened fruit has been better than that from fruit not completely ripened. Apple seed from Baldwin, Rhode Island Greening, and Tompkins King has given low germination and seedlings of poor vigor. On the other hand Winesap, Wealthy, Ben Davis, Delicious, and Rome Beauty have given good seed and vigorous seedlings. That the pollen parent plays an important part is shown by crosses between McIntosh and Baldwin, Rhode Island Greening, and Delicious. With Baldwin as the pollen parent only two seedlings developed from 114 seeds; with Rhode Island Greening as the male parent, no seedlings grew; while with Delicious as a male parent 62 seedlings came from 94 seed. It is not surprising, therefore, that seed from orchards of the Pacific Northwest has proven satisfactory.

Domestic Myrobalan plum seed has given good germination regardless of source. Peach seed of Carolina naturals has germinated better than seed from some California canning peaches. Seed from certain commercial pear varieties such as Bartlett, Beurre d'Anjou, Garber, Kieffer, Sudduth, and Winter Nelis, has germinated well.

Next to sources of seed, different distances of planting have had the greatest effects in seedling production. From one lot of Mahaleb seedlings grown the season of 1927 the grades for different distances apart in rows all three feet apart is shown in Table I. The records

TABLE I—GRADES OF MAHALEB SEEDLINGS AS AFFECTED BY PLANTING DISTANCE

Plants per Foot	Total Number	Average No. per Row	Percentage Graded as			
			1/4″ and over	3/16″ to 1/4″	2/16″ to 3/16″	Below 2/16″
4	1,004	334	14.98	76.13	4.79	4.06
10	1,730	865	0.22	61.78	16.83	21.14
12	1,059	1059	0.75	58.73	18.88	21.62
14	2,274	1137	0.48	56.95	16.15	26.39
18	1,446	1446	0.00	46.61	20.74	32.64

are similar from other lots totalling 40,000 Mahaleb seedlings, while for apples, Table II shows not only a correlation between size and distance, but also indicates the importance of even distribution over a given area rather than close together in rows. These findings are in agreement with the methods in use in foreign seedling producing sections.

TABLE II—SIZES OF APPLE SEEDLINGS AS AFFECTED BY PLANTING DISTANCE

Treatment	Percentage Graded as					Plants per sq. ft.
	8/32″	6/32″	5/32″	4/32″	2/32″	
In rows 6″ apart and thinned	6.5	21.8	20.4	40.1	10.9	16
In rows 6″ apart, unthined..	0.4	0	4.2	15.5	79.8	60
Broadcast and thinned.....	1.5	6.9	20.0	39.3	32.0	91.2
Broadcast unevenly........	1.0	4.8	12.4	34.5	47.2	84

Not only have fertilizers not been profitable, but also it is questionable whether they have given any response whatsoever. A glance at Table III reveals a strong correlation between distance and size but not between fertilizers and size.

TABLE III—EFFECT OF FERTILIZERS UPON MAHALEB SEEDLINGS

Applications	Number of Plants per Row	Percentage Graded as			
		1/4″ and Over	3/16″ to 1/4″	2/16″ to 3/16″	Below 2/16″
None	847	1.65	43.32	17.70	37.30
Ammonium sulfate, 1,000 lbs. per acre	865	0.46	44.85	17.91	36.76
Calcium Nitrate, 3,000 lbs. per acre	878	3.41	43.05	19.39	34.16
Urea, 250 lbs. per acre	918	0.10	49.78	18.51	31.59
Urea, 500 lbs. per acre	1134	0.70	38.44	16.75	44.09
Urea, 1000 lbs. per acre	1207	0.91	34.29	19.63	45.15
None	1235	0.48	35.87	17.48	46.15
Ammonium sulfate, 2,000 lbs. per acre	1322	0.23	33.43	17.17	49.16

As for the production of branch-root seedlings, certain varieties and species of apples, such as Whitney and *Malus baccata*, have given a high proportion of straight roots; while others, such as Winesap, have given many well-branched roots. Seedlings of Mazzard, Mahaleb, and Myrobalan have been sufficiently branched to meet trade demands, but in most cases apple and especially pear seedlings have developed unsatisfactory straight roots.

Transplanting was resorted to to meet this situation, the seedlings of all classes being started in cold frames and transplanted to the field in early spring. Comparison was made between dibbling, transplanting with especially constructed planting boards, and transplanting by machine. In all cases the necessity of having the roots placed straight in the soil was emphasized, otherwise developing a high proportion of so-called "goose necks." The planting board method has proven best adapted to American conditions, though machines are promising. The chief difficulty with machines, namely in slowing them down, has been met, but as yet the loss of plants is too high to make machine planting practicable.

The most satisfactory, and best branch-root apple and pear seedlings have been produced by transplanting, and with planting boards. On the other hand transplanting seedlings of Mahaleb, Mazzard, and Myrobalan were little or no improvement, so far as root system is concerned, over stocks from seed without transplanting. It was possible, however, in some instances, on account of increased size, to bud transplanted seedlings of *Prunus* species the first season, as is done in the case of the peach from seed. Transplanting as early as when the first leaves were forming gave better stand and larger plants than when done at later stages of development. Apples and pear seedlings have responded well to transplanting. Mazzard cherry seedlings, on the other hand, have frequently been either severely stunted or destroyed by leaf-spot before recovery from the check attending transplanting.

Because the cost of transplanting is prohibitive at present market prices of branch-root seedlings, the cheaper two-year method was tried in which seedlings are grown close together during one season so as not to grow too large, dug at the end of the season, and lined-out in rows the following season for further growth. The sizes produced the first season from different distances of planting may be seen from Table II, while the grades of seedling stocks produced by these grades in turn when grown an additional year in rows three feet apart are shown in Table IV. This method in the case of the pear and apple

TABLE IV—Second Season Growth of French Crab Seedlings of Different Sizes

Size When Planted	Number	Graded When Dug as			
		1/4″ and Above	3/16″ to 1/4″	2/16″ to 3/16″	Below 2/16″
2/16″ and below	1425	0.0%	37.8%	52.6%	14.4%
2/16″ to 3/16″	736	0.0%	53.2%	46.7%	0.0%
3/16″ to 1/4″	256	20.3%	50.0%	29.7%	0.0%

has given a grade of seedlings not so good as transplanted seedlings, but better than those not transplanted. Unless the one-year seedling roots are cut off not too far from the crown the side roots that develop may be so distant from the crown as to be removed in trimming, thus eliminating the very factor striven for. Furthermore, leaf-spot on French pear stock may be a serious factor, resulting in fine, hairy, weak lateral-root development.

While in the case of the apple and pear the principal problems are those of making sufficient growth and of securing branch-roots, the problems with cherries seem largely those of seed supply and of handling the seedlings after thay have been produced. Preliminary evidence shows clearly that cherry stocks are seriously affected by premature digging and by careless handling after digging, whereas apple seedlings though not benefited, are not so easily injured by similar treatment.

The Vigor of Apple Seedlings

By F. E. GARDNER, *University of Maryland, College Park, Maryland.*

THE prospect of complete exclusion of apple stocks into the United States from other countries by Federal Quarantine has awakened considerable interest in their domestic production. A report of the Federal Horticultural Board for 1928 (1) shows that domestic grown apple stocks now furnish by far the major part of the total supply for this country, and that about one-third of the total supply in sight for 1928 is from domestic seed. During the past five years increasing use has been made of seedling stocks grown from seeds obtained from cider apples of commercial varieties, particularly from the northwest. This use of varietal seedlings as stocks, however, has been made without the consideration that some varieties might produce better and more vigorous seedlings than others.

Among other characteristics generally considered to be desirable in root stocks is vegetative vigor. It has been reported that vigorous apple seedlings, when budded, produce larger nursery trees than seedlings which are relatively lacking in vigor (4), and that nursery trees which are large as the result of vigorous stocks usually remain relatively large and productive when planted in the orchard, as compared with smaller trees (3).

Work is now in progress in the United States Department of Agriculture to test seedlings of different open-pollinated varieties for desirability as stocks, although the male parents are unknown. Though it is important to know which of our varieties as female parents will produce the best seedlings, it would seem of equal importance to learn the effect of the male parent. Lantz and Merrill, (2), working

TABLE I—HEIGHT GROWTH OF SEEDLINGS, 1927

Parentage	Number of Seedlings	Average Height in Cms.*	Standard Deviation**	Coefficient of Variability
1. Delicious x N. W. Greening.....	20	44.8 ±2.98	13.45	30.0
2. Delicious x Williams.	9	37.1 ±1.01	6.31	17.0
3. Delicious x Jonathan.	32	31.2 ±1.99	10.73	34.4
4. Delicious x McIntosh.	77	28.2 ±0.98	8.07	27.6
5. Delicious x Rambo ..	18	22.0 ±1.16	4.70	21.3
6. Delicious x Rome....	17	21.7 ±3.85	5.61	25.8
7. Delicious x Yellow Transparent........	112	20.3 ±0.62	6.17	30.4
8. Delicious x Grimes...	36	10.8 ±0.405	2.22	20.5
9. Delicious x Gano....	20	9.6 ±0.47	2.04	21.2
Entire group with each cross in equal proportions.............		25.07±0.62	12.90	51.3

*P. E. M. by Bessel's Modified formula.
**Calculated whenn.·is infinite for each cross.

with seedlings of Antonovka as the female parent have shown that the vigor of seedlings from this variety may vary with the pollenizer used. However, they were concerned chiefly with vigor as an essential quality of new varieties and therefore discarded all obviously weak seedlings before planting in the orchard.

The present work, although only preliminary in nature, deals with the effect of the male parent on the vigor of Delicious seedlings. Delicious as the female parent has been crossed with nine other varieties. The seeds were planted in flats in the greenhouse in early spring and later transplanted to cold frames. The following table shows the height growth of the seedlings in relative order of vigor at the end of the first season, 1927.

In order to have a larger progeny of each cross for observation in 1928 it was planned to increase the number of plants by root cuttings. Due to the transplanting in 1927, however, the seedlings did not develop the usual long tap-root which is ideal for root cuttings, but instead had numerous fibrous roots too small for propagation purposes. For this reason it was decided to grow the seedlings another year before making root cuttings. At the end of the first season the seedlings were dug, the tops entirely removed, and the root crowns replanted in the cold frames, but in a different order than in the previous year. Top growth in 1928 came from basal buds of the seedlings, and, since the first year's top growth had been removed, was the result of root influence only. Table II shows the average top growth of the various crosses in 1928. Since no selection has been practiced, the results are based on the measurements of all the seedlings regardless of the amount of growth they exhibited.

TABLE II—HEIGHT GROWTH OF SEEDLINGS, 1928

Parentage	Number of Seedlings	Average Height in Cms.*	Standard Deviation	Coefficient of Variability
1. Delicious x Williams	7	66.2±4.33	18.6	28.1
2. Delicious x N. W. Greening	17	59.5±4.38	27.6	46.4
3. Delicious x Rome	21	53.5±3.10	21.7	40.5
4. Delicious x Jonathan	33	50.0±2.62	22.8	45.6
5. Delicious x McIntosh	65	46.5±2.21	24.6	52.8
6. Delicious x S. Rambo	18	44.6±4.22	27.5	61.7
7. Delicious x Yellow Transparent	114	41.4±1.43	22.8	55.0
8. Delicious x Grimes	53	31.8±1.39	15.2	47.7
9. Delicious x Gano	27	28.0±2.08	17.0	60.7
Entire group with each cross in equal proportions		45.7±1.02	25.2	55.2

*N. sometimes appears larger than in Table I since a few trees had to be excluded in 1927 due to destruction of a portion of the tops by rabbits.

From the tables it appears that there is a marked difference in the vigor of the seedlings of various crosses. The coefficients of odds between the most vigorous and the least vigorous groups in 1927 and 1928 are 11.65 and 7.95 respectively, giving enormous odds that the differences are significant. Whether or not the seedlings of Delicious would make good stocks as far as vigor is concerned seems to depend to a large extent upon the inheritance from the male parent. Theoretically the male parent should be of equal importance with the female.

In support of the first year's results are those of the second year. Almost the same relative order of vigor of the different crosses in

1927 is maintained in 1928. The exchange of position between Williams and Northwestern Greening as male parents is not significant when considered in relation to the probable errors. It is interesting, however, that even though the actual difference in growth between two adjacent crosses is generally not statistically significant, the same order of vigor is maintained closely over two years.

Not only does the male parent influence the vigor of the seedling but it also seems to affect the variability. The coefficients of variability in 1927 show the progeny of each cross to be less variable than the entire group of seedlings, which may be considered for comparison as a group of seedlings of unknown male parentage. More variability is exhibited in 1928 than 1927 and two of the crosses appear to be more variable than the entire group.

The range of vigor in the second year is not so pronounced as in the first year. This suggests that there may be a tendency to overcome differences in vigor between crosses in later years, although this tendency may be due largely to the growth stimulus given all the seedlings by cutting them back to the ground at the end of the first year. On the other hand, the larger coefficients of variability in 1928 suggest that the differences of vigor between individuals within each cross may become greater in later years.

Further Studies Important: The present results consider only nine varieties as male parents and therefore probably do not demonstrate the range of vigor it would be possible to secure if more pollenizers had been used. It should be determined whether these same male parents, when crossed with several other varieties as female parents, will impart to their progeny the same relative order of vigor as they have to Delicious seedlings. The fruits resulting from pollination studies, instead of being discarded, might well be used in this work to secure carefully bred seedlings for determining which varieties transmit the factors for vigor, and might therefore be good parents for seedling stocks.

Practical Application: As a practical method of securing vigorous seedlings for stocks the tedious procedure of hand pollination would scarcely be justified, but seedlings could be obtained from natural crosses in cases where the male parent is known with a reasonable degree of certainty. Such a plan would of course be feasible only with self-unfruitful varieties pollenized by varieties known to transmit vigor to their progeny. To test the practicability of this plan, seeds have been collected this year from Stayman and Declicious apples taken from orchards or blocks in which only one other variety was present as the pollenizer. Seedlings of these natural crosses are to be grown the coming season.

Literature Cited

1. Conference on fruit and rose stocks. Fed. Hort. Board, June 27, 1928.
2. Lantz, H. L., and Merrill, S. Apple breeding. The vigor of Antonovka seedlings. Proc. Amer. Soc. Hort. Sci., 115–120. 1927.
3. Sax, K., and Gowen, J. W. The place of stocks in the propagation of clonal varieties of apples. Genetics, 8:458–465. 1923.
4. Sax, K. Bud and root selection in the apple. Maine Agr. Exp. Sta. Bul. 344. 1928.

Variability of Vigor in Apple Seedlings

By GEORGE H. DICKSON, *Vineland Station, Ontario, Canada*

IN this paper, age of parent variety is discussed as a possible cause of variability of vigor in seedlings. What constitutes age in a fruit variety is not known. Certain old varieties seem to be as productive now as they ever were, while other varieties of more recent origin appear to have deteriorated. Rapid deterioration has been noted at the Ontario Horticultural Experiment Station in "seedling" strawberries and raspberries particularly. In the Niagara District of Ontario, the Crawford type of peach, embracing a number of varieties, has become noticeably less productive in the past 15 or 20 years. It is doubtful if this change in productiveness, with which is associated other weaknesses, can be attributed entirely to cultural practices, depleted soil, seasonal conditions, etc., especially as some varieties, old and new, continue to do well. The suggestion therefore is that, while the date of introduction of a variety indicates, in a general way, its age in years, yet constitutionally the variety may be old or young for its years. This probably is not a frequent condition, but, if it occurs at all, may account for certain discrepancies in the accompanying table.

Nor do we know how the seeds of certain varieties of apples germinated and grew when these varieties were young in years. Systematic plant breeding with fruits has been carried on for too short a time to give us this information. We do know, however, that certain old varieties, Baldwin and Greening for example, have been characterized by plant breeders as of little value as seed parents, due to weak progeny. As pollen parents also, they are little, if any, better.

In the following table is given the average seed content and the percentage of germination of seed of a number of apple varieties. Also there is given the percentage pollen germination of a few varieties as given by E. Kvaale in the Memoirs of the Horticultural Society of New York, Vol. III, page 399. The last column of the table, in which date of origin of the various varieties is given, has been compiled from information secured from "Apples of New York," by Beach and "Cylopedia of Hardy Fruits" by Hedrick.

There seems to be some correlation between age of a variety and seed content, the older varieties being generally lower in seed content. Also the low seed content is apparently correlated with poor seed germination and weak growing seedlings, as later indicated.

Study of the table indicates that the average seed content for a variety is fairly constant. Variations within a variety from year to year, may be ascribed to weather conditions during the blooming period or to differences in nutrition. The relative differences between varieties remains approximately the same throughout. Certain varieties in the table seem out of place. The Stark for example, has a low seed content, but appears as a comparatively new variety. However its origin is obscure which, in itself, indicates that it is probably much older than the date noted, 1892 (listed generally). In fact, if

TABLE I—RELATION BETWEEN AGE OF A VARIETY AND SEED CONTENT, SEED GERMINATION, AND POLLEN GERMINATION

Variety	Grand Average Seed Content	Seed Content (Aver. of 25 Fruits)				% Seed Germination		% Pollen Germination (Kvaale)*	Approx. Date of Origin
		1920	1922	1927	1928	1921	1928		
Belle de Boskoop	1.50			1.52	1.48		27.54		1856 Seed
Baldwin	2.06			2.52	1.60		19.00	12.3	1740 about
Rolfe	2.47	3.80	2.85	2.40	2.64	13.0	43.73		1820 "
Blenheim	2.85	2.83	3.42	2.64	2.68	10.7	42.85[1]		1818 In London Nurser's
Arctic	3.04	3.08		3.00		5.00	30.55		1862 As a seedling
Stark	3.27	3.56	3.64	2.60		8.05	50.00[1]		1892 Listed generally
Gravenstein	3.28	4.56			2.00	16.5		13.0	1826 Intro. to America
Greening, R. I.	3.32			2.32	4.32		8.33	28.0	1748 about
Ribston	3.63	4.36		3.32	3.20		22.9	21.4	1700 about
King	4.09			3.80	4.56		20.00		1804 Orig. tree moved
Smokehouse	4.09			4.56	3.80		11.00		1837 Then long prop.
Nero	4.29	5.88	3.52	3.48		7.4	26.00		1889 Reference to it
Hurlburt	4.37	4.52	4.32	4.28		15.6	30.43		1849 Tree flourishing
Stayman	4.53	5.40	4.12	3.08		11.5	16.33	6.5	1866 Sdlg. Winesap
Arkansas	4.58	5.68	4.24	4.00	4.40	6.0	18.33	11.4	1833 from seed
Ontario	5.62			5.56	5.68		45.00		1874 First described
Ben Davis	5.66	6.80		4.52		42.6	65.00		Before 1800
Ottawa	5.69	6.88		5.52	4.68	55.2	40.66		1898 Seed planted
Collins	6.28	7.00		5.80	6.04	77.7	80.33		1865 about
Wagener	6.50			7.20	5.80		20.66[2]		1791 Seed planted
Scots Winter	6.56			6.56			74.34	45.3	1864 about
McIntosh	6.60			6.08	7.12		50.00	56.9	1796, prop. began 1870
Scarlet Pippin	6.68	6.48			6.88	23.2			1860 about
Gano	6.68	7.24	7.76	5.04		30.9	61.66		1880 Brought to Mo.
Princess Louise	6.69			6.69			52.33		1879 Fruit exhibited
Hubbardston	6.76	8.32		5.52	6.44	16.6	47.04		1832 Noted as desirable
Pewaukee	6.85	6.88		7.84	5.84	50.3	68.88	83.6	1870 brought to notice
Windsor Chief	7.16	9.00	6.52	5.96		24.0	87.33		1889 First described
Jonathan	7.19	8.32		6.52	6.64	36.0	23.00[2]		1826 Very valuable by
York Imperial	7.22	7.48		6.96	7.28	37.1	61.00		1830 Began propagating

Fameuse	7.26			6.04	8.48		75.47		At least 200 yrs. old
Adonis	7.28	7.76	7.44	6.64		10.3	66.15		1898 Seed planted
Yel. Belleflower	7.36	7.84	7.16	7.08		8.1	30.00		1817 Tree very old
Delicious	7.44	7.24		7.52	7.56	48.1	71.66	89.6	1881 found, 1895 prop.
Winter Banana	7.71	7.88	7.12	8.12		3.8	21.00		1876, prop. began 1890
Suttons Beauty	7.87	8.52		7.48	7.60	18.7	54.00		1848 Brought to notice
Cranberry	7.98			8.40	7.56		71.66		1845 Downing praises it
Shiawassee	8.16			7.04	8.28		45.00		1850 Began bearing
Canada Red	8.18	8.76		7.60		60.3	75.00		By 1822 names confused
Wealthy	8.25			8.40	8.10		61.25	85.9	1860 Seed procured
Cayuga	8.27	10.72		5.80		30.6	21.00		About 80 years ago
King David	8.30	8.32		8.28		45.3			1893, In fence corner
N. W. Greening	8.35	10.4	7.04	7.32		14.5	40.00		1872 Introduced
Mann	8.52	9.40		7.64		44.6	89.66		1870 about
Peerless	8.66	9.00		8.32		10.4	46.60		1867 Originated
Cora	8.67	8.90		8.44		45.1			1898 Seed planted
Kitchener	8.92			8.92	8.92		77.66		
Grimes	8.93	8.44		9.64	8.72	47.8	50.66		1804, fr. orig. tree sold
Forest	9.06	7.64		11.20	8.36	24.2	64.33		1850 about
Walbridge	9.31			10.52	8.10		33.80		1818 Descr. 1870 R.N.Y
Rome	9.73	12.24	7.80	9.16		21.4	61.66	90.5	1848 brought to notice
LaSalle	10.42	10.32		10.52		26.00			Sdlg. Newman, Quebec
Niobe	10.76			10.76			66.66		1898 Seed planted
Boiken	11.11	13.24	9.88	10.12		27.6	75.00		1859 Reference
Salome	11.11	12.20		11.28	9.84	53.7	68.33		1853 Originated
Wismer's D.	11.66	12.84			10.40	52.0			1897
Claire	12.12	12.12				62.8			1898 Seed planted
Magog	12.83	14.52	11.26	12.72		16.1	40.00[3]		1876 reference
Newtown	13.57	14.56	13.48	12.68		37.05	64.00		1759 Fruit sent to Eur.

[1]Although the germination here was satisfactory the seedlings were decidedly lacking in vigor.
[2]Jonathan and Wagener not mulched properly in frames 1927 thus the poor germination 1928.
[3]Magog seeds are so plump the seed coat of many are burst, this may account for the poor germination.
*Kvaale percent pollen germination from Memoirs of the Hort. Society of N. Y. 1926, pp. 399.
The seed content averages are for twenty-five fruits from each variety.
Seed germination averages were computed from a minimum of 300 seeds except in rare cases.
The 1920 seeds were planted in flats, which on the whole have proven unsatisfactory, and thus we find a lower seed germination in 1921 than in 1928 when all seeds were planted in cold frames and properly mulched.

one studies the table carefully it will be seen that there is considerably more doubt as to the actual age of the first named and low seed content varieties than there is for the higher seed content varieties appearing on the latter half of the table. Generally it seems safe to assume greater age for those varieties having obscure origin than for those whose origin is fairly definitely known.

As grown at Vineland, Stayman ranks low as to seed content and, according to Kvaale, its pollen germinates poorly. On the other hand, Yerkes gets vigorous seedlings from Stayman at Washington. Climatic adaptability or nutritional differences may be the explanation for these variations. Fameuse and Newtown, both very old varieties, probably among the oldest we have, rank well up in seed content. Newtown is especially high with an average of over 13 seeds. Both varieties give moderately vigorous seedlings, suggesting "constitutional" youth though old in years.

As a whole, however, the evidence seems to support the assumption that, with age of variety, abnormalities occur which cause low seed content, poor germination of seed, and lack of vigor in the seedlings. Similar evidences of lack of vigor in seedlings from old varieties have been noted at Vineland among other fruits. Seedlings of Concord and Niagara grapes are generally weak, the latter particularly so. Reine Claude plum seedlings are conspicuously lacking in vigor.

The above paper is not presented with the idea of attempting to definitely prove age as a cause of degeneracy of the reproductive organs of the various apple varieties. Age is however suggested as a possible cause. The table indicates that possibility and is presented on its own merits. The fruits examined were all taken from a variety orchard which would insure good pollination, and as the average seed content remains relatively constant over a period of years the seed content must be fixed by other causes than pollination.

The seed from the low seeded varieties germinates poorly, perhaps due to after-ripening conditions of the seeds, but the resulting seedlings are weak and within a variety are uniformly so, which would seem again to eliminate the pollen factor and further emphasize the weakness to be in the mother parent.

The seeds were treated alike. When the fruit was mature, varying from picking time for the early varieties to late January for others, the seed was removed and planted out in a cold frame which had been prepared in advance and ready to receive the seeds as soon as taken from the fruit. Position in the frame seemed to have no influence on germination and it was only these low seeded varieties which germinated poorly and grew poorly, so that these three factors seem linked together, namely low seed content, poor germination and weak seedlings.

When the age of varieties was considered these fell into a group of very old varieties, which, also from the evidence of Kvaale, gave poor pollen germination. Age is, therefore, offered as a possible cause of sexual degeneracy in apple varieties.

The Influence of Clone Roots on the Variability of Young Apple Trees*

By R. D. Anthony, *Pennsylvania State College, State College, Pa.*, and G. E. Yerkes, *United States Department of Agriculture, Washington, D. C.*

THERE are many indications that the number of orchard experiments based on the use of clone roots will increase rapidly. Clone roots are also beginning to get into commercial plantings. The chief reason at present for their use either in the commercial or the experimental orchard is to produce a block of trees with a greater degree of uniformity. Whether or not the use of clone roots has made it possible to produce young trees showing greater uniformity is the question which led to the present paper.

In the spring of 1927 two lots of one-year Stayman trees were planted on a piece of soil, uniform as soils go. One of these consisted of 108 trees on French crab stocks from a commercial nursery. These were unusually fine trees with a mean height of $142.04 \pm .38$ cm. and had been carefully graded to one size, as the nurseryman knew they were to be used for experimental work. The other lot was 81 trees propagated on a clone stock, T-200 developed by the United States Department of Agriculture and propagated at the Arlington Experiment Farm. Owing to the limited number of trees available, this included a wider range of sizes than the other lot. The mean height was 142.01 ± 1.04 cm., a probable error nearly three times as large as the commercial trees. Both these lots had been propagated by budding one or two inches above the ground level. Both were shaped at planting by the debudding method and practically no pruning has been necessary since then.

In studying these trees the coefficient of variability has been used as a means of expressing their relative uniformity in a concrete way.

The greater uniformity of the commercial Stayman trees at the time of planting as compared to those on clone roots is shown by the coefficient of variability for weight, height, and diameter, in each case the second figure being the clone trees: $C\hat{w} = 17 \pm .76$; $C\hat{w} = .30 \pm .15$; $C\hat{h} = 4 \pm .02$; $C\hat{h} = 10.4 \pm .05$; $C\hat{d} = 7 \pm .03$; $C\hat{d} = 10 \pm .04$.

At the end of the growing season the 1928 branch growth and the circumference increase since planting were measured for each tree. For the branch elongation the coefficients of variability of the two lots of trees are: $C = 24 \pm .15$, $C = 31 \pm .17$; for circumference increase they are: $C = 14 \pm .09$, $C = 18 \pm .09$. From these figures it appears that the more uniform sizing of the trees on commercial seedling roots has continued to maintain a higher degree of uniformity through two years in the orchard. Such results were not unexpected at this stage of growth, whatever may develop later due to the clone roots.

*Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 470.

This continuation of the influence of uniformity of the material at planting places emphasis on the performance of trees in the nursery. If uniform material is wanted for planting it is desirable that a high degree of uniformity be secured in the nursery.

In 1927 in the nursery at Arlington Farms, Washington, D. C., height measurements were taken of one-year Winesap and McIntosh trees, each budded on three groups of stocks, namely, mixed French crab roots from several different sources, seedlings from each source being kept separate; open-pollinated seedlings from several known varieties; and clones of American selection.

When all the Winesap trees worked on French crab stock were grouped, the coefficient of variability for height was 14 ± .65 with a mean height of 120.5 ± 1.1 cm. A study of the frequency curves of the French crab trees from the five different sources which were grouped for the above record, showed all practically alike in variability and vigor. When the Winesap trees on roots of known female parentage were grouped they seemed more variable than the French crab seedlings (C = 17 ± .96), with a mean of 123.5 ± 1.7 cm.; but when the trees on seedlings of a single parent were studied separately the uniformity of the material was increased. Thus 17 trees on Delicious seedlings gave C = 7 ± .81 while the mean increased to 137.1 ± 1.5 cm. Fourteen Winesap trees on Grimes roots gave C = 8 ± 1.02 with a mean of 137.5 ± 2.1. McIntosh and Smokehouse seedlings gave somewhat more variable results. When all the Winesap trees which were worked on clone roots were grouped, their coefficient of variability with respect to height was somewhat less than either of the other large groups (C = 12 ± 1.07), the difference being statistically significant in the case of the seedlings of known parentage. The mean increased to 131.8 ± 2.1 cm. The trees on an individual clone were less variable than the group; one, Vermont 316, having a C = 4 ± .72 with a mean of 142.7 ± 1.7 cm. The McIntosh trees practically duplicated the results with Winesap trees. With these trees, as far as height records are concerned, the use of seedlings of known female parentage seems to have increased uniformity but not as much as the use of clone roots. In this latter group also, selected clones produced superior trees, as judged by height, though different clones differed in vigor.

In 1928 there was another block of one-year Stayman in the Arlington nursery also worked on three classes of stocks, namely, mixed seedlings both of French and domestic origin, seedlings from named varieties subject to open pollination, and clone roots. At digging time these trees were calipered in millimeters, five centimeters above the bud. Table I gives the results of the analysis of these data.

With the exception of two types, one of which made an irregular start at planting and which, it is thought, was influenced by a field variable, the clone roots produced more uniform nursery trees than the mixed seedling roots which correspond to the usual commercial roots. The small number of Stayman on each lot of roots from seeds of known female parentage gives such high probable errors to the coefficient of variability that the interpretation of this group is uncertain.

TABLE I—A STUDY OF CALIPER OF ONE-YEAR STAYMAN ON ROOTS FROM VARIOUS SOURCES

Parentage of Roots	No. Trees	Coefficient of Variability	Mean mm.
Mixed seedlings			
Domestic	217	30.7±1.08	13.0
French crab	66	34.0±2.21	12.15
Named parent			
Delicious	14	25.6±3.45	13.4
Grimes	14	19.6±2.58	14.2
Y. Newtown	15	25.3±3.30	12.8
Ark. Black	16	30.7±3.98	13.12
Clone			
Type 12	418[2]	25.3± .62	13.4
Type 13	213[2]	21.9± .74	12.8
Type 15	216[2]	23.6± .83	13.7
Vermont 312[1]	81	20.5±1.12	13.4
Vermont 317[1]	145	29.7±1.27†	11.12
Vermont 323[1]	85	26.8±1.48	12.12

[1]Developed by U. S. D. A.
[2]From East Malling Research Station, England.
†Variability probably increased by field conditions.

The 1928 nursery records as shown in Table I also agree with the 1927 records in showing that seedlings from one female parent may be more uniform than those from another parent and that two clones may also differ in uniformity.

In conclusion the results indicate that if uniformity in growth is expected in the early years in the orchard, trees should be planted of uniform size whether on clone or seedling roots. The use of clone roots in at least four out of five cases has resulted in greater uniformity in the nursery experiments reported.

Responses of Variety and Seedling Roots To Attempts at Propagation

By W. H. Upshall, *Experiment Station, Vineland, Ontario, Canada,* and F. E. Gardner, *University of Maryland, College Park, Md.*

THE propagation of apple stocks from seedling root pieces is now a relatively simple and practical method of securing uniform stocks. Mr. G. E. Yerkes, of the United States Department of Agriculture, who has developed this method to a high degree, has been using it quite extensively to propagate clonal stocks from individual seedling apple trees which appear outstanding in vigor and pest resistance.

When it was found that seedling apples could be propagated so successfully from root cuttings, it seemed that the problem of growing commercial varieties on their own roots was solved. It appeared that all that would need to be done would be to secure the varieties on their own roots and then make cuttings of these varietal roots for all future propagations. True, it has been possible to grow varieties on their own roots by the arduous methods of layering and by long-scion, short-root-piece grafts (1), but these methods are relatively expensive and time-consuming for practical purposes. The root-cutting method, on the other hand, seemed to present itself as being superior to the usual method of budding or grafting on seedling stocks in point of view of time and expense, and would eliminate the factor of variability usually attributed to seedling stocks.

Contrary to expectations, variety root cuttings have, in all cases, given very disappointing results. The work on these cuttings has been in progress since 1925, and the authors now have some 50 apple varieties on their own roots from which root pieces are taken for attempts at propagation. Each year the trees are dug, a portion of the roots removed, and the trees are headed back and then replanted to grow more roots. These root cuttings have been planted in soil, sand, and sand-peat moss mixtures, both in the greenhouse, and in cold frames during the winter and spring months. The following table serves to indicate the difference in behavior between seedling and varietal root pieces. Root cuttings from one year old French Crab seedlings have been used for comparison with varietal roots.

Varietal roots:	4079 cuttings,	134 rooting,	or	3.28 per cent.
Seedling roots:	337 cuttings,	271 rooting,	or	81.00 per cent.

No attempt is made in this short paper to show the variation which exists between varieties, since all the varieties tried gave poor results in comparison with seedling roots. Yerkes (3), however, has shown that there is a difference in the percentage of roots of different varieties to grow, even though the amount of growth is generally very unsatisfactory.

The difficulty with varietal root cuttings seems to lie in their inability to produce new roots. Many of them produce buds and may even make a short growth without forming new roots, but such plants soon die. Even though a few do form new roots the plants

usually are weak and grow very slowly. At the U. S. D. A. Station at Shafter, California, good vigor is apparently secured from at least some varietal root pieces, for Mr. L. B. Scott, writes, "We secure a top growth of four to five feet in one season from varietal root cuttings and from our root cuttings propagated from selected seedlings, which we have carried through three vegetative propagations, we secure a growth of from six to eight feet in one season." At Shafter planting is done in December or January in the open and furrow irrigation is given about once a week during the spring and early summer.

Some of the larger variety roots were bench-grafted with scions of several varieties and planted directly in the field with checks comparable in size made up on the same scion varieties on one-year French Crab seedling root pieces, i.e., ordinary nursery grafts. In the former, callusing was poor and the stock showed little activity when planted while the latter gave all indications of a quick start into growth. As might be predicted from the results on varietal root cuttings, the grafts on variety roots were nearly a complete failure while the checks produced an average nursery stand of trees. Shaw (2) also has reported poor results with scions on variety roots but attributed it to other causes than the inability of the variety root piece to grow. He states, "It seems hardly reasonable to suppose that such poor results must necessarily follow grafting on the roots of known varieties."

A few of the varietal root cuttings which did grow, produced new roots of sufficient size for cuttings the following year. From such new roots 21 cuttings were secured and 9 of these grew, or 42.9 percent. This suggests that if one could so invigorate the few cuttings which do grow, one might be able to successfully produce trees from root pieces taken from selected plants,—a vigorous strain thus being produced.

If one could return to the original seedling trees of commercial varieties and secure root pieces from those trees, propagation of the varieties might then be carried on by root cuttings. It should be pointed out, however, that propagation from old seedling trees, regardless of the age of the root piece itself, is not so successful as when the root pieces come from very young trees. Although most of our original variety seedling trees are now dead, many new varieties are continually being produced and some are proving to be of commercial value. It would seem wise to start propagating all new seedlings by root cuttings as soon as they show promise of being of value. The older the tree, the more difficult becomes this method of propagation.

The authors believe that the marked difference in behavior between seedling and scion roots is to be explained eventually by their difference in origin,—seedling roots having their origin in the seed or true root tissue, while scion roots spring from the stem, presumably from the cambium. This difference in origin may give rise to important differences in structure or nutrition to account for their

response to propagation attempts. In fact, differences in structure and nutrition have been found by the authors and are being further investigated in the hope of finding a complete explanation, if not a remedy, for the difficulty.

Acknowledgments

The writers wish to express their gratitude for the gift of material and for helpful suggestions from Mr. G. E. Yerkes and Mr. L. B. Scott of the U. S. Department of Agriculture and to acknowledge the co-operation given by Dr. E. C. Auchter, now of the U. S. D. A. and Director E. F. Palmer of the Ontario Horticultural Experiment Station.

Literature Cited

1. Auchter, E. C. An experiment in propagating apple trees on their own roots. Proc. Am. Soc. Hort. Sci., 205–211. 1925.
2. Shaw, J. K. The propagation of apple trees on their own roots. Mass. Agr. Exp. Sta. Bul. 190. 1919.
3. Yerkes, G. E. Propagation of apples by root cuttings and layers. Proc. Am. Soc. Hort. Sci., 93–98. 1926.

New Wraps for Buds and Grafts

J. A. McClintock, *University of Tennessee, Knoxville, Tennessee*

THIRTY years ago, when the author was learning to tie buds in a commercial nursery in southern Michigan, string and raffia were the wrapping materials used. While nurserymen admitted then that both string and raffia had their faults, these two materials have continued in use for want of something better.

Studies on crown gall control and the attempt to reduce excess callus formation in bench grafts have resulted in the production of an adhesive tape by manufacturers of medicated surgical tape. Rolls of this tape ¼ inch, ½ inch and 1 inch in width and 36 yards in length were supplied for test purposes. It was stated in correspondence that any width tape could be furnished, and that each width could be supplied in 60-yard rolls. In 36-yard rolls these nurserymen's tapes retail at 40 cents per roll for the ¼ inch; 55 cents for the ½ inch, and 85 cents for the inch widths. On large quantities it is understood that the above prices will be considerably reduced.

Used as wraps for buds we preferred ¼ inch or ½ inch widths because a longer strip of tape was required, and more tension could be applied to hold the bud in close contact with the stock. Less time was required in wrapping the various widths of tape because they did not slip on the stocks while tying, and did not require hitches at bottom and top to keep them from unwinding. A good set of buds was obtained with the adhesive tape wraps, and there were fewer faulty unions such as occur in string wraps.

The objections to the adhesive tape are that under field conditions it is inconvenient to stop and cut each strip of tape as used. If the tape was cut into strips 6 to 12 inches in length instead of 36-yard rolls it would facilitate use in the nursery row. The adhesive substance used on the tape soon coats one's finger tips so that they collect much of the dirt that comes in contact with them. The tape adheres so tightly to the stock that it is necessary to unwind it to avoid girdling. The outer layer of bark on the stock adheres to the tape when it is removed. Whether this is a serious objection remains to be seen. Slitting of the adhesive tape opposite the bud does not release the wrap as in the case of string or raffia; therefore, more work is required for the removal of the tape wrap. When applied to the stocks above ground we saw no indication that the adhesive tape used would decay and release the stock before girdling occurred. The manufacturers are experimenting with different spreads of adhesives and types of gauze to overcome the above difficulties. Some of the objections raised in the case of adhesive tape used as bud wraps in the field would prove less serious in the case of bench grafts.

The newest wrap which we have tested is a rubber strip, sold in two sizes. The smaller averages 3½ inches long, ⅛ inch wide and $\frac{1}{32}$ of an inch thick. There are about 2400 of these strips per pound. The larger size is about 4 inches long, $\frac{3}{16}$ inch wide and $\frac{1}{32}$ inch thick. This size contains about 1120 strips per pound. These wraps retail at the same price, that is, $1.20 per pound.

Graft Affinity Tests With Peach on Myrobalan and Marianna Plums

By W. L. Howard and M. J. Heppner, *University of California, Davis, Calif.*

ONE phase of our extensive rootstock investigation has been a study of Myrobalan and Marianna plums as possible stocks for peaches. There were three reasons for our interest in the two stocks mentioned: first, because we are trying all possible combinations among stone fruits in our affinity tests; second, the Marianna has been said to tolerate the nematode or eel worm; and third, the Myrobalan is more resistant to oak-fungus (*Armillaria mellea*) and more tolerant of heavy soils and high water table than the peach.

On the whole, seedlings of both Myrobalan and Marianna might be said to be unreliable as peach stocks because of the great variation in vigor and lack of uniformity in their affinity for the peach. So variable are they in these respects that each tree might almost be said to represent a distinct type. We have tested 75 types of Myrobalan alone. One at least of these is almost 100 percent perfect as a stock for peaches, while others are practically 100 percent failures with all gradations between. Apparently there are similar variations among Marianna seedlings, although we have not tested them so extensively. It seems quite certain that desirable types of either stock, when found, will have to be propagated asexually. Fortunately many of the Myrobalan types can be grown from ordinary hardwood cuttings. The Marianna is especially easy to propagate in that way.

Strangely enough all the types we have tried of both Myrobalan and Marianna appear to take peach buds as readily as peach seedlings do and also to unite as well with the wood. In spring when the stock has been cut back in the usual way the buds start to grow in a normal manner and continue growing like other nursery trees until about the first of August and have attained a height of four to six feet, when many of them suddenly die. Death occurs without any previous symptoms as far as the parts above ground are concerned.

Upon examination it is found that the roots die before the tops. Apparently death starts at the tips of the roots and progresses upward until the entire vascular system of the central axis of the underground part of the tree is involved. It would appear that at a certain stage of their existence the leaves and stem parts become unable to transfer synthesized materials to the roots, and they thus die of starvation. Seemingly the vessels continue to function for water transfer until the last minute, as the leaves retain their normal appearance up to the time they suddenly collapse. When a sprout has arisen from the root it is observed that the part it is attached to remains alive after the peach top and main root system have died.

As before stated types of both Myrobalan and Marianna vary in their ability to support the peach throughout their year in the nursery; also the variety of peach has something to do with it. These

points were determined by propagating as many as 75 types of Myrobalan and two types of Marianna, both by seeds and by cuttings, and budding them to 29 varieties of peaches. The varieties most commonly used were Elberta, Lovell, Phillips, Ontario, and Mayflower. Others consisted of Tuscan, Muir, Sims Cling, Paloro, Orange Cling, Hauss Cling, Levy, Susquehanna, Red Bird Cling, Early Crawford, Alexander, St. John, Late Crawford, Peaks Cling, Selma, Libbee Cling, Foster, J. H. Hale, Heath Cling, Briggs Red May, Salwey, Lemon Cling, Lemar, and Strawberry Cling.

Of all the varieties we have tried, Ontario and Lovell make the largest and healthiest trees, and a larger percentage survive the year in the nursery. During the season of 1928, 34 percent of the Ontario trees on Myrobalan lived until leaf-fall in the nursery, while only 20 percent of Elberta on the same stock survived the nursery year. The average for all varieties was 26 percent. While these figures are relatively correct they are misleading; all the figures should have been higher as the budding was done under unfavorable conditions. Ontario makes its best growth on Myrobalan, on the average, while Mayflower does best on Marianna.

A development of the Mayflower in 1928 is worth mentioning as it brings to the fore the interesting question of influence of stock on variety. In the spring of 1928, after taking out all trees that were needed for permanent plantings, the remainder were left in the nursery row. This collection represented a large number of peach varieties, all on seedling Myrobalan stock. Most of the trees were of good size, that is from five to six feet in height, and in a few cases they had set fruit buds. Being undisturbed they made a vigorous growth the second season, that is, in 1928. At the close of the second season they were eight to twelve feet high and averaged about three inches in diameter six inches from the ground.

The Mayflower in particular bloomed and set fruit in a number of the blocks, each of which represented Myrobalan stock grown from the seeds of a particular tree. It was interesting to observe that many of the types evidently exerted an influence on the date of ripening. The trees in one block in particular ripened their fruit fully two weeks earlier than the normal date for this variety as shown by comparing them with bearing trees in our variety orchard. Among the other blocks were trees that ripened a few days early, about the normal time, and as much as two weeks late.

These trees will be allowed to stand during the season of 1929 and perhaps longer, in order that this particular phenomenon may be studied further. Another year should show whether other varieties are influenced like the Mayflower. Possibly also the quality of the fruit may be influenced, too, but the time of ripening is of the greatest importance, particularly with the so-called early fruits that are so extensively grown in parts of California. It is the early fruit that brings the high prices, and if the ripening date on an early variety can be hastened by only a few days the economic importance to the industry would be hard to estimate.

What the fate of peach trees on Myrobalan and Marianna stock will be after they have been planted in the orchard is yet undetermined. We have some on Myrobalan stock that have been four seasons in the orchard and others a less time. Apparently they continue to die off to some extent, but on carefully selected types this may be prevented. Our oldest trees are on miscellaneous seedling stock, and we now know that some types are very unreliable. We yet have much to do in selecting desirable types. At the present time we have picked one particular Myrobalan that we think will be a winner for all purposes. It certainly is promising as far as we have gone with the tests, but we may find others that have equal merit.

While our affinity studies have already led us somewhat astray we expect to continue to work in this field and at the same time follow up as many of the fasicnating sidelines as possible. After all sometimes a side road leads to more interesting things than the main highway if one is not in too much of a hurry to reach his original destination.

Investigations in Rooting Blueberry Cuttings

By STANLEY JOHNSTON, *South Haven Experiment Station, South Haven, Mich.*

THE difficulty of propagating selected varieties of blueberries has, to a considerable degree, curtailed their extensive planting. Large areas of land suitable for blueberry growing are available and probably will be planted when plants can bo obtained in larger numbers and at a lower cost.

During the past four years the South Haven Horticultural Sub-Station of the Michigan Experiment Station has been investigating the rooting of cuttings of varieties of the high bush blueberry, *Vaccinium corymbosum*, including Rubel, Pioneer, Cabot, Adams, Harding, and Katherine.

Many methods of rooting blueberry cuttings have been tried during the course of this investigation including the use of hardwood and softwood cuttings; cold frames, hot beds, and solar frames; use of various materials as rooting media; and the use of various chemical treatments. During the course of the investigation the solar frames proved to be so much more efficient than cold frames and hot beds that in 1928 they were used entirely. The solar frame is not new, having been used by investigators in Washington working on citrus propagation. Data for 1928 are quoted in this paper, as they best indicate the general trend of the investigation.

Sand, peat, peat moss, and various combinations of peat and sand were used as rooting media. The data presented in Table I show the results obtained with these various materials.

TABLE I—ROOTING CUTTINGS IN VARIOUS MATERIALS

	Rubel		Adams	
	Number	Per cent Rooted	Number	Per cent Rooted
Softwood Cuttings				
German peat	75	86.6	30	86.6
American peat	75	40.0	30	90.0
German peat and sand	75	6.6	30	10.0
Sand	75	10.6	30	13.3
Harwood Cuttings	Rubel		Pioneer	
German peat	22	90.9	15	86.6
Sand	22	0	15	0

The data in Table I show great differences in the number of rooted cuttings when various materials were used in the cutting beds.

The hardwood cuttings were all taken about April 1 and placed in the cutting beds at once without storing. The softwood cuttings, however, were taken at intervals between July 5 and August 23, the results being shown in Table II.

Approximately the middle of July proved to be the best time for taking softwood cuttings, while cuttings taken August 23 not only failed to root to any extent but fruit bud differentiation had already

TABLE II—TIME OF TAKING SOFTWOOD CUTTINGS
(German peat used as rooting medium)

	Rubel		Pioneer		Cabot	
	No.	Per cent Rooted	No.	Per cent Rooted	No.	Per cent Rooted
July 5	42	83.3	35	71.4	18	88.8
July 13	54	100.0	38	92.1	27	100.0
July 23	38	81.6	24	58.3	15	100.0
Aug. 1	32	87.5	22	50.0	14	71.3
Aug. 7	35	82.8	25	60.0	13	76.9
Aug. 23	34	0	23	8.6	13	23.0

taken place and all of the lateral buds developed differentiated flower parts. However, due to the differences in growing seasons in the same and different sections of the country, probably the condition or stage of development of the new growth would be a better index as to the proper time for taking softwood cuttings than exact dates. The blueberry plant makes an initial period of growth early in the growing season, usually terminating the latter part of June or the first part of July in Southern Michigan. Secondary growth then takes place from a few of the lateral buds. It has been observed that the best time for taking softwood cuttings, regardless of date, is just as the secondary growth is starting.

Several investigators having reported success with chemical treatments in rooting cuttings of other plants, some of the most promising materials were used in this experiment. The solutions were made at the strengths indicated in Table III, and the cuttings were allowed to stand in the solutions for 24 hours.

TABLE III—CHEMICAL TREATMENTS WITH HARDWOOD CUTTINGS
(German peat used as the rooting medium)

	Rubel		Pioneer	
	Number	Per cent Rooted	Number	Per cent Rooted
K Mn O_4 .001 mol. sol.	22	100.0	15	86.6
K Mn O_4 .01 mol. sol.	22	100.0	15	93.3
$K_3Fe (Cn)_6$ .001 mol. sol.	22	100.0	15	100.0
Na_2O_2 .001 mol. sol.	22	95.6	15	80.0
Mn So_4 .001 mol. sol.	22	90.9	15	73.3
Cu So_4 .001 mol. sol.	22	95.6	30	66.6
Acetic Acid (.52% vinegar sol.)	22	95.6	15	100.0
Sucrose (2% solution)	22	95.6	15	93.3
Check	22	90.9	15	86.6

While it is apparent that in some instances somewhat better results were obtained with the use of certain chemical treatments, the differences are not great enough to indicate that these treatments are of any great value.

Observation has shown that temperature is an important factor in rooting blueberry cuttings. Some investigational work with reference to temperature control has been started but the work has not been under way for a sufficient length of time to draw any definite conclusions.

The Japanese Apricot as a Root-Stock*

By CLAYTON O. SMITH, *Citrus Experiment Station, Riverside, California*

THE flowering apricot of Japan, *Prunus mume*, is used in its native habitat as an ornamental and is especially desirable because of its abundance of fragrant flowers, produced in winter or early spring. At Riverside, California, trees frequently are in flower about January 1st, and from this time on for two months or more different individual trees continue to come into flower. This species blooms about the same time as the Peento or Saucer peach, and almonds. The flowers are single, semi-double and double on different trees; they are white, rose and occasionally of different shades of red, are apparently very hardy to frost, being able to withstand several degrees below 32°F. without injury. The trees at Riverside fruit abundantly, the fruit forming and reaching considerable size before the leaves appear. The fruit vary in size but on some trees they approximate that of the Royal, our most popular commercial apricot. For the most part, the fruit is produced on the abundant short spiny spur-like growth. It is very sour and scarcely edible. In Japan a kind of sour pickle is made of the fruit.

The interest in this species grew out of its apparent resistance to artificial puncture inoculations with the crown gall organism, *Pseudomonas tumefaciens*. The results (2) from five thousand such inoculations showed about 6% infection. Some gall were typically spherical while others were small point like growths, probably abortive initial infections.

This root according to Morrow (1) is resistant to nematode root-knot, to *Armillaria* root rot and "apparently quite resistant to crown gall."

No scientific description has been found of the adaptability of this species as a rootstock for the different varieties of Stone fruits. From some correspondence with horticulturists of Japan, it is evident that the species is not used there as a commercial rootstock because of the difficulty of grafting to other varieties. No mention was made of other experience in propagating upon it by budding.

Through the cooperation of the U. S. Bureau of Plant Industry, Division of Plant Introduction, pits of *P. mume* (Seed and Plant Introduction number S. P. I. 47950) were imported from Japan and an experimental planting to be used for rootstock tests was started at the Citrus Experiment Station in 1920. The seedlings grew well and were budded in August of the year of planting and those that failed were again budded the following August. These budded trees were planted in orchard form in the spring of 1923.

Five commercial varieties each of peaches, almonds, Japanese plums, prunes, and apricots, were propagated on this stock by budding, as follows: Peaches—Lovell, Elberta, Alexander, Muir, and Tuscan;

*Paper No. 185, University of California, Graduate School of Tropical Agriculture and Citrus Experiment Station, Riverside, California.

almonds—Nonpariel, I. X. L., Ne Plus Ultra, Texas, and Drake; Domestica plums—French, Italian, Grand Duke, Sugar, and Tragedy; Japanese plums—Beauty, Burbank, Santa Rosa, Satsuma, and Wickson; apricots—Blenheim, Hemskirk, Royal, Tilton, and Moorpark. Four trees of each variety were included in the orchard plantings.

The trees were examined frequently, and after four seasons' growth the following were the conditions recorded (Table I).

TABLE I—MEASUREMENTS OF GROWTH OF SCION AND *Prunus mume* STOCK, AND IN SOME CASES OF AN INTERSTOCK. THOSE STARRED HAVE A THREE-YEAR OLD TOP. ALL OTHERS HAVE BEEN GROWING FOUR YEARS IN THE ORCHARD.

Variety	Roots	Diameter Stock	Diameter bulge or Inter-stock		Diameter Scion	Height of Scion
		Inches			Inches	Feet
P. domestica	*P. mume*					
Sugar	*P. mume*	4.0	Bulge	5.0	4.0	12
Sugar	*P. mume*	3.5	Bulge	4.5	4.5	12
Sugar	*P. mume*	3.5	Bulge	4.0	3.5	12
Sugar	*P. mume*	3.5	Bulge	4.5	4.5	12
*Tragedy	*P. mume*	2.0	Tribble P. D. Stock	1.8	2.0	8
*Tragedy	*P. mume*	1.9	Tribble P. D. Stock	1.7	1.6	7
Tragedy	*P. mume*	6.0	Bulge	6.0	5.0	12
*French	*P. mume*	2.5	Bulge	4.0	4.0	10
French	*P. mume*	4.0	Bulge	5.0	4.0	8
P. salicina						
Beauty	*P. mume*	4.0	Bulge	5.0	4.0	7
Burbank	*P. mume*					
*Santa Rosa	*P. mume*	4.0	*P. armeniaca mandshurica*	4.0	4.0	12
*Santa Rosa	*P. mume*	3.5	*P. armeniaca mandshurica*	2.75	3.0	10
*Santa Rosa	*P. mume*	9.0	Bulge	12.0	5.5	12
Satsuma	Own	—	Smooth	—	5.0	15
Wickson	Own	—	Smooth	—	5.0	15
*Wickson	*P. mume*	4.0	*P. armeniaca mandshurica*	3.5	3.5	12
P. armeniaca						
*Blenheim	*P. mume*	4.5	Smooth	—	4.0	10
Tilton	*P. mume*	7.0	Smooth	—	5.5	15
Tilton	*P. mume*	7.5	Smooth	—	6.0	15
Amygdalus communis						
*Ne Plus Ultra	*P. mume*	4.0	Peach Bulge	7.0	4.0	8
Ne Plus Ultra	*P. mume*	4.0	Bulge	5.5	4.0	12
Texas	*P. mume*	3.5	Bulge	5.0	3.75	10
Texas	*P. mume*	6.0	Bulge	7.5	6.5	12
Drake	*P. mume*	5.0	Bulge	6.5	5.0	12

The apricots of the commercial varieties listed had made excellent growth, being 15 feet in height, and with as much spread of branches. The bud unions were found to be perfect with no overgrowth. It is almost impossible to detect the point of union, so uniform is the growth of scion and stock.

Four Satsuma plum trees 12 to 15 feet high are for the most part on their own root, although it is difficult to be sure of this in all cases. They have made excellent growth.

The Santa Rosa and Wickson plums have grown well, but Burbank and Beauty plums have shown feeble growth and evidence of incompatibility. Three Wickson trees (15 feet high) are growing, one on its own roots, and the other two double-worked with *Prunus armeniaca* var. *mandshurica* as interstock. The two Santa Rosa trees were also double-worked with the same interstock as Wickson because the unions of both these varieties broke out from the *P. mume* stock. They and the Wickson plum have made excellent growth and have well developed tops and satisfactory smooth unions.

One Santa Rosa plum tree, growing directly on *P. mume* root, merits further consideration, because of the increase in size of the scion as compared with stock; the scion is 5.5 inches in diameter and bulges to 12 inches at the union with the *P. mume* trunk which is 8 to 10 inches in diameter. The tree is growing vigorously, being about 12 feet high. The scion shows overgrowth, directly above point of union, which is situated some distance below the surface of the soil.

At the end of the third season the varieties of *P. domestica* had made a satisfactory growth with the exception of Grand Duke and Imperial which had suffered from delayed foliation. Tragedy has three trees growing and has made the largest growth of all the varieties tested, being 10 feet high at the close of its second season in the orchard. The following spring two of the three trees, 3.5 and 4 inches in diameter, broke off at the point of union. One of these old roots sprouted and was double-budded with a type of Domestica that has been used as a rootstock to a limited extent, and on this Tragedy was budded. The growth after three years is 8 feet high with a smooth union of practically uniform diameter of scion and stock, but with some smaller diameter of interstock. These relations are shown in Table I.

After four seasons' growth the Sugar prune now shows the best growth. All four trees are growing directly (without interstock) on the *P. mume* root and are doing well. They are about 12 feet high and the trunk is 3.5 to 4.5 inches in diameter. The union of one tree is smooth while the others show slight enlargement or bulging on one side (Table I). French prunes on *P. mume* from a greater overgrowth than Sugar and have grown about 12 feet in height.

The almonds and peaches have not for the most part made satisfactory growth. There is marked overgrowth (except with Lovell) and much dwarfing with abundant fruit-bud formation. Some of the varieties of almonds such as I. X. L. and Nonpareil have died, while others are still alive after four years. Three Ne Plus Ultra almond trees are still growing. One is of the original planting, while the other two were replanted and double-worked on peach as an interstock. The tree directly on *P. mume* root is 12 feet high and shows a bulge of 5.5 inches on the scion above the bud union. The almond and the *P. mume* trunk on either side of the bulge are each 4 inches in diameter. One of these double-worked almond trees on peach as an

interstock has grown vigorously but has a decided bulge of the peach interstock which is 7 inches in diameter, with the almond and *P. mume* trunk on either side 4 inches in diameter. In the other Ne Plus Ultra almond the peach interstock has itself rooted.

Four Texas almonds 7 to 12 feet high, all of the or'ginal planting are evidently dwarfed somewhat and have much fruiting wood but lack new vegetative growth. Three Drake almonds are still living, but are dwarfed, being only 6 to 8 feet high. All show bulging of the scions.

Of the peaches tested, Lovell has grown the best, but all varieties in this experiment showed some delayed foliation. Four Lovell trees are alive; three of them on *P. mume* root are from 10 to 12 feet high, while one, partly on its own root, is much larger and more vigorous. The unions are smooth with no overgrowth.

Considerable difference in growth and other characteristics of these budded trees were observed in the nursery. The apricots made exceptionally vigorous growth, followed closely by the Domestica and Japanese plums. Trouble was experienced with Wickson and Santa Rosa plums, both of which formed a brittle union. Almonds in the nursery grew well, but some varieties of peaches, as Muir, showed the first season an abnormal condition with rolled leaves that lacked the normal green color. They never became normal.

The seedlings of *P. mume* used varied much in vigor, many being so small that they were discarded. A more vigorous strain seems desirable for use as a stock. *Prunus mume* is somewhat difficult to bud successfully, because of its thin bark.

Some miscellaneous nursery observations of varieties budded on *P. mume* may be of interest as indicating their future behavior. The following were the species and varieties budded on *P. mume: P. domestica*, Clyman, also a *P. domestica* stock reintroduced by Tribble nursery; *P. bokhariensis* (S. P. I. 40229); Methley plum (*P. salicina* x *cerasifera*); Minnesota No. 145 (*P. besseyi* hybrid); Peento-almond hybrid (*A. persica* x *A. communis*); *Amygdalus davidiana; A. mira;* Beaty plum (synonymous with El Paso, *P. angustifolia* x *P. munsoniana*); and *P. armeniaca* var. *mandshurica*, Sharp plumcot.

P. bokhariensis grew rapidly at first when budded on *P. mume*, but within a short time showed a brittle union that broke out in almost all cases. When it was grafted on *P. mume*, a marked overgrowth developed at union.

Methley plum makes a remarkable growth in the nursery when budded on *P. mume*, and shows only a slight overgrowth. There is no question but that the scion would form roots of its own if the union was planted deeply since cuttings take root.

Minnesota No. 145 makes an excellent growth the first year in nursery on *P. mume* root. It seems to support a peach top, but would probably cause dwarfing as the Minnesota is a small tree.

Beaty seedling (*P. munsoniana* x *P. angustifolia*) are now under test as an interstock for peaches. They grow well when budded on *P. mume*, but show some breakage. Elberta and Lovell peaches

budded into vigorous growing Beaty seedlings have shown smooth satisfactory unions. After two years in the orchard the trees are still vigorous with heavy crowns 10 feet high.

Scions of *Prunus* and *amygdalus* worked on *P. mume* often show certain forms of overgrowth that are closely correlated with dwarfing. This is in agreement with observations (3) (4) of lemon budded on sour orange. The plum unions, however, show reactions somewhat different from those of citrus fruits. This drawfing is most notable with peach, almond, and some of the Japanese plums and slightly so with *domestica* varieties. A suitable interstock would give a smoother union and probably a larger tree. Some tests with interstocks are now under way, but are not sufficiently advanced to make any recommendations. The following prunus forms are promising for experimental trials as interstocks since they seem to make a smooth, strong union when budded on *P. mume*: *P. domestica* (Clyman) and Tribbles stock, *P. besseyi* hybrid (Minnesota No. 145), *P. armeniaca*, *P. armeniaca* var. *mandshurica*, Sharp plumcot, and selected seedlings of Myrobalan, *P. cerasifera*. Lovell peach gives only a slight overgrowth at union with some dwarfing and should be further tested as an interstock.

Conclusions

P. mume as a rootstock behaves very much like *Prunus armeniaca*, the common apricot. It has not given much promise as a stock for any of the stone fruits except the apricot, for which apparently it can be safely used. Its strong and weak points as a stock for the apricot, however, can only be determined by experimental tests in various localities. It is too early to say that the *P. mume* root can not be used for the Japanese and Domestica plums if the proper interstock can be discovered. This stock gives very little promise for almonds and peaches, but even here further search should be made for a suitable interstock which will adapt the *mume* root to these varieties.

Literature Cited

1. Morrow, J. E. *Prunus mume.* U. S. D. A. Bur. Plant Industry. Plant Immigrants No. 214:1962–1963. 1924.
2. Smith, Clayton O. Crown Gall studies of resistant stocks for prunus. Jour. Agr. Res., 31:957–971. 1925.
3. Webber, H. J. Rootstock reactions as indicating the degree of congeniality. Proc. Amer. Soc. Hort. Sci., 23:30–36. 1926.
4. ———. The lemon rootstock problem. California Citrograph, 11:388–401. 1926.

A Peculiar Performance of Some California Blue Plum Scions

By C. F. Kinman, *U. S. Department of Agriculture, Sacramento, Calif.*

IN 1920 it was observed that a few trees and certain branches of other trees of the California Blue variety of plums were performing differently from neighboring trees or the other branches of the same tree in fruit production and leaf growth. A few trees were bearing a heavy crop while most trees were bearing but a very few fruits, if any; and on a number of trees were one or more branches which were bearing heavily while the remainder of the same tree was unproductive. About one-third of the trees under observation were bearing a full crop of fruit on one or more branches. There has been a striking difference in the size of leaves on bearing and nonbearing branches and trees. In their fruiting years the leaves of the fruiting branches and trees have always been much smaller than in years when they did not fruit. There are numerous other varieties of plums in the orchard, but no difference in performance among the trees of any of them could be seen.

There are 68 trees of the variety under observation in the orchard where the striking difference in behavior was noted. These trees are in three adjoining rows which have 22, 23, and 23 trees respectively. The trees are 20 feet apart in the row and the rows 20 feet apart.

All of the trees are top-grafted, plum scions having been grafted into peach branches in 1913. At this time the peach trees had reached bearing age and the base of the framework branches had reached a diameter of about 2 to 2½ inches at the time of grafting. In preparation for grafting, the peach tree branches were headed back leaving stubs a few inches in length. Two or three scions were inserted in each stub depending upon the size of the branch that was cut back. The latter number were used in but a few cases. There were from 3 to 5 grafted branches on each tree and most of the plum scions grew, so that now the trees have from 5 to 10 main framework branches which grew from the scions. There is a total of 460 scions growing in the 68 trees.

In 1920 the crop of fruit on the 68 California Blue trees was exceedingly light, except for 7 entire trees and one or more branches of 19 other trees. On the 7 trees and the bearing branches of the others the crop was very heavy or about equal to a normal crop for trees of this variety in their fruiting year. Twenty-six bore on one or more of their scions. A total of 94 of the 460 scions that make up the 68 trees fruited heavily that year. The accompanying table gives the location in the row of trees which fruited on one or more of these scions in 1920, the number of fruiting scions and the performance of these scions in succeeding years.

Trees of the California Blue variety have a strong tendency toward bearing on alternate years only. The crop is usually excessive one year and only a few fruit are produced the following year.

In each alternate year commencing with 1920, or in the years of even numbers, the crop has been light on most trees and scions except those which fruited in 1920; and in the years of uneven numbers the crop has been heavy except where there was a crop the previous year. In the light crop years most trees bore less than a dozen fruit and some of them not a single fruit. In their fruiting season trees set from two to four thousand fruit each. Since the trees are small and cannot bring all the fruit to a marketable size, much of it is pulled off when it is partly grown leaving only a thousand or so to ripen.

While the fruiting habit of all trees and scions in the block of trees under consideration was very well defined when it was first observed that some scions bore in different years than others, there has since been a gradual change in some of them in regard to the constancy of their alternate bearing habit. In 1920 eight of the 26 trees that were found fruiting bore on only one scion, two trees bore on two scions, five on three, three on four, one on five, one on six and seven on all seven. In each succeeding year the number of scions which bore fruit in 1920, or on the alternate year from the main crop, has decreased in number until in 1925, which was the sixth season that the performance of the trees was recorded, only 31 of the original 97 scions performed differently than the majority of the trees of this variety. Twenty-six of these were on 4 of the trees which were made up entirely of fruiting scions in 1920. Only one tree which is made up of both branches which do and which do not bear in the same year continued their peculiarity after 1925. This was Tree 11 in Row 3. Eleven trees of this type had conformed to the habit of the majority. In 1927 three of the seven trees which bore on all their scions in 1920 continued to produce their crops on opposite years with the majority of the trees. These are Tree 25, Row 1; Tree 9, Row 3; and Tree 10, Row 3. Where there was but one scion on a tree that bore in 1920, the "off" year for most trees of this variety, the scion in most cases remained contrary only a short time compared with trees which were made up entirely of off-year bearing scions; and now most of them are indistinguishable from the remainder of the trees in their fruiting performance or their leaf growth.

Where two or more scions on the same tree bore in 1920, one or more of these scions performed differently from the others in the amount of fruit borne in a number of cases. In three instances, notably in Tree 15, Row 1, and Trees 11 and 26, Row 2, the scions which bore in 1920 became more or less annual bearers thereafter. In this respect they differed from any scions which did not bear in 1920. None of the trees which did not bear in 1920 has since borne more than a very light crop in any year of even number.

Although the habits of some scions which bore on the "off" year changed so that they bore with the majority, the tendency to fruit on the opposite year recurred in a few instances, notably, Tree 11 and 24 of Row 2; and Tree 14, Row 3.

During the period these trees have been observed a number of peculiar instances of variation in the fruiting performance of a part

of a tree have been noted. Some of these are mentioned here. In 1920 no fruit was borne on Tree 4, Row 1, except on one twisted branch. In 1924 no fruit was found on Tree 15, Row 1, except on one twig which was loaded with fruit. In 1924 one scion of Tree 13, Row 2, produced no fruit although up to this time it had performed the same as the main part of the tree. In 1925, Tree 25, Row 1, bore on some of its scions, contrary to their alternate bearing habit. A few isolated spurs on otherwise nonbearing trees have been found fruiting heavily. In some cases there was but one bearing spur on the tree. The inclination of trees or parts of trees of this variety to perform independently of the remainder of the tree or of other trees is well illustrated by the bearing habits of these trees, branches, twigs, and spurs. Only in the instance of the one twisted branch has there been any indication that the fruiting of any of the spurs, twigs, or branches may have been induced by a mechanical injury.

In the orchard with the California Blue trees are a number of other varieties of plums which were all top-grafted on peaches at the same time and in the same manner as was employed with the California Blue trees, but no variation in bearing habits among scions of any of these varieties has been seen.

In another part of this orchard a number of top-grafted trees of the California Blue were found where there was considerable variation as to the year in which the tree bore. Some scions bore heavily one year while others had no fruit. The same difference in performance of scions top-grafted on peach was found with California Blue trees in another orchard which is a few miles from the one discussed here.

The cause for the variation in fruiting habits of entire trees and single branches under observation has not been determined, but the frequence of scions that differ from the majority in somewhat isolated sections of the rows suggests that some of the scions used in grafting were taken from trees which fruited one year and the others from trees which fruited the opposite year. In Row 3, trees numbering from 4 to 11 inclusive, with the exception of No. 7, have three or more scions which bear on opposite years from the majority of trees of this variety. On trees No. 9 and 10 in this group all scions bear, making it appear probable that a bundle of scions taken from trees that bore on the opposite year from the majority were used in grafting these trees. The same is suggested by the group of a few trees near the end of the rows. It may be noted that Tree 25 of Row 1, Trees 24, 25, and 26 of Row 2, and Tree 24 of Row 3 bore on almost all their scions in years of even numbers.

Some incompatibility between the plum scions and the peach stock is indicated by enlargements that have developed at the base of each scion. In many cases the stubs of the peach branches did not heal over after being grafted, and decay has entered. Weakness caused by this decay has resulted in the loss of a few branches and the weakening of many trees. Studies of the graft unions, enlargements at the base of the scions, and the trees which have been affected by decay yield no explanation of the variation in the fruiting

TABLE I—FRUITING RECORD OF SCIONS OF CALIFORNIA BLUE PLUMS WHICH FRUITED IN 1920[1]

Row	Tree	Number of Scions Fruiting in 1920	1920	1921	1922	1923	1924	1925	1926	1927
1	4	1	1-m[2] xo[3]	1-l x-o	1 br.	—[4]	—	—[2]	—	—
1	15	3	2-l 1-h x-o	2-m 1-l x-h	3-h x-o	3-l x-h	1 br.	—	—	—
1	24	1	1-m x-o	1-m x-h	—	—	—	—	—	—
1	25	all 7	all h	all l	all h	all l	all h	4-l x-h	all h	o
2	5	1	1-h x-l	all m	1-l x-o	—	—	—	—	—
2	8	3	3-h x-l	3-l x-m	—	—	—	—	—	—
2	9	1	1-h x-o	1-m x-h	—	—	—	—	—	—
2	11	4	4-h x-o	1-o 3-l x-h	4-m x-o	—	—	—	—	—
2	13	1	1-h x-o	1-o x-h	1-h x-o	1-l x-h	4-m x-o	—	—	—
2	16	2	2-h x-o	all m	1-h x-o	—	1-o x-m	—	—	—
2	17	1	1-h x-o	—	—	—	—	—	—	—
2	20	2	2-m x-o	—	—	—	—	—	—	—
2	24	3	3-l x-o	—	—	—	—	—	—	—
2	25	4	2-m 2-h x-m	2-m 2-l x-h	—	—	3-l x-o	—	—	—
2	26	all 8	all h	all m	all m	all m	—	—	—	—
3	4	4	4-h x-o	4-m x-h	—	—	—	—	—	—
3	5	all 8	all h	all o	—	—	—	—	—	—
3	6	3	1-h 2-m x-o	1-m x-h	—	1-l x-h	1-d x-m	—	—	—
3	8	3	1-h 2-m x-o	2-m x-h	2-l x-o	—	1-l x-o	—	—	—
3	9	all 7	all h	all o	all h	all l	all h	all o	all h	all o
3	10	all 6	all h	all o	all h	all o	all h	all o	all h	all o
3	11	5	5-h x-o	5-o x-h	4-h x-o	5-o x-h	5-h x-o	2-o 2-l x-h	5-h x-l	—
3	13	1	1-h x-o	1-o x-h	—	—	1-o x-h	—	—	—
3	14	1	1-m x-o	—	—	—	—	1-o x-h	all m	—
3	15	all 8	all h	all o	all h	all l	all h	all m	all h	all m
3	24	all 9	8-h 1-o	8-o 1-h	all h	all l	all h	all l	all h	all m

[1]The trees and scions not included did not bear in 1920, but did bear in 1921 and in alternate years following. All scions of these trees performed alike.

[2]Letters indicate the size of crop: h = Heavy crop, l = Light crop, m = Medium crop, o = No fruit. x = All other scions of that tree.

[3]The notes regarding the performance of certain scions in the different years refer to scions which fruited in 1920.

[4]The blank spaces indicate that peculiarity in bearing habits of scions noted in 1920 are no longer apparent and that all scions of the tree perform the same and fruit the same year as do the majority of the trees of the orchard, which is in years of uneven numbers.

performance of the scions but rather lead to the belief that they have had no influence whatever upon it. The advancement of the wood decay and the accompanying weakness of the trees and branches has had no effect upon the alternate bearing or excessive bearing habits of these trees and branches in their fruitful years. The scions with excessive enlargements near the base have not been found to perform differently from those with small ones.

The Time of Flower Bud Formation in the Dunlap Strawberry

H. W. RICHEY and J. C. SCHILLETTER,[1] *Iowa State College, Ames, Iowa*

SINCE the productivity of our fruit plants is determined by the formation of flowers and the development of those flowers or parts of them into fruits it was thought advisable to have a more complete knowledge of the flower bud formation of the strawberry in order that we might better understand the responses of the plant to those practices that are used in an attempt to increase its yields economically. Such a study was started with plants set at Ames, Iowa, in 1924, and with the exception of the plants grown in 1926, which were destroyed, the work has been continued each year.

This report will deal with the plants grown during 1924, 1925 and 1927. Only one noticeable change has been made in the methods reported in a previous paper by Ruef and Richey (1). During the first year of the study all plants occupying the same numerical position on the different runner series were collected and studied as a group. It was decided, however, that much more accurate information could be obtained if each of the two thousand or more plant crowns was killed, embedded, sectioned, and studied separately. This change greatly increased the amount of work necessary but by such a change the life history of each plant was secured from the date it was formed to the day it was prepared for microscopic study. A standard method was followed for the preparation of such vegetative material for cytological study. Beginning in late August, representative plants were dug at about two-week intervals until early November.

By a runner series is meant the runner plants in a single connected string of plants arising from the mother plant. Each mother plant was limited to five of these unbranched series. All other plants were removed as soon as noticed. This system of training resulted in a mother plant with five runner series on each of which there were eight to ten runner plants. The number of runner plants on a runner series varied with the season and with the time at which the collection was made.

[1]The writers are indebted to J. U. Ruef, A. H. Finch and Max B. Hardy, who as graduate students at Iowa State College, worked on this problem.

The study was made chiefly, to determine the time[2] of differentiation of flower buds; to determine if there was a relationship or association of the age of the plant, its position in the runner series, and its approximate leaf area, with the time of flower bud inception and rate of flower development; to determine the relationship of. environmental factors as temperature and moisture to flower bud formation; to determine the order of formation and rate of development of the flowers on the same fruiting stalks; and to determine the relative time of initiation and rate of development of flowers and flower stalks in plants of similar and different ages.

The first collection of plants was dug late in August of each year. Neither the mother plants nor any of the runner plants showed indications of flower bud differentiation at the time of the first digging. The plants collected each year about September 10th, showed differentiation in some of the first and second plants of the various runner series but no differentiation was noticeable in the mother plants. The plants collected late in September showed differentiation in the mother plants and in all the first and second runner plants.

There was a progressive differentiation of flowers from the oldest plant to the youngest plants on a runner series. By about the middle of October the flower stalks of mother plants and those of the first and second runner plants had reached approximately the same degree of development. These were followed in order by the other plants in the runner series with less differences being shown by the oldest plants. By November all but the very youngest plants showed flower bud formation. By the time growth ceased in the Fall the development of floral parts was much more advanced in 1927 than it was in 1924, and slightly more in 1924 than in 1925. In both 1927 and 1924 pistil formation was noticeable on some of the oldest plants whereas in 1925 no formation of pistils took place on any of the flowers before growth ceased in the Fall. Thus it is seen that flower bud formation was first noticeable in early September, and that differentiation took place first in the oldest runner plants, then the mother plant, and then in turn in the youngest runner plants on the series; and that the oldest plants maintained their lead throughout the season.

While more flowers are being formed on a flower stalk, those already differentiated continue in the development of the various floral parts. The rate of development in different flowers of the same flower stalk remained quite uniform and constant especially in the oldest plants. A smaller number of flowers were formed by the last two or three plants in a runner series. The interval between the time of appearance of the primary flower and the time of appearance of the secondary flower was longer in the youngest plants and longer the later in the season that differentiation took place. The flower development, after once begun, was as rapid if not slightly more rapid in the individual flowers on the youngest plants than it was on the oldest ones. While the secondary flowers appeared at

[2]Time of flower bud formation is taken to mean that time at which morphological differentiation is visible microscopically.

approximately the same time on the opposite sides of the flower stalk, one was always slightly in advance of the other, and the tertiaries that developed on the more precocious secondary were slightly in advance of those tertiaries that appeared on the more backward secondary.

It was found that the age of the plant, its position in the runner series, and its leaf area were associated with its degree of floral development at different periods. The oldest runner plants were the first to show differentiation of flowers, and possessed the most advanced stage of development at all times. There was considerable difference in the ages of plants occupying the same numerical position in the different runner series. The difference in the time of appearance of flower primordia and the rate of flower development was less in these plants than was their differences in ages, that is, the youngest plants formed flowers in a fewer number of days than did the oldest plants. Furthermore, plants of the same age occupying different positions on the runner series showed different degrees of floral development. It was found that the oldest plants had the largest amount of leaf surface.

Obviously neither the age, position of the plant in the runner series, or leaf area alone determine the time of flower bud formation in the Dunlap strawberry. Lack of moisture and low temperature seemed to hasten flower bud formation noticeably. Flower buds were first noticed after a period during which the soil had become a little dry and vegetative growth had been slowed up slightly. In one season, after such conditions prevailed, heavy rains fell while the temperature was still quite high. Vegetative growth, as indicated by runner formation, was increased, and the rate of flower bud formation and development was lessened. A decided drop in temperature late in the Fall was followed each year with a marked checking of vegetative growth and increased flower bud formation and development, even though the soil was well supplied with moisture. Apparently, drought and cold weather caused a checking in the rate of vegetative activity and this was accompanied by a rapid increase in the formation and development of flowers.

Literature Cited

1. Ruef, J. W., and Richey, H. W. A study of flower bud formation in the Dunlap strawberry. Proc. Am. Soc. Hort. Sci., 252–260. 1925.

The Effect of Shade Upon Fruit-Bud Differentiation

By W. PADDOCK and F. G. CHARLES, *Ohio State University, Columbus, Ohio.*

THE writers have long been of the opinion that the main fruit-bud determination of the apple, takes place at an earlier date than is shown by miscroscopical examination. They have also thought that this determination may take place within a comparatively few days. They have arrived at these conclusions because of the following facts: The commercial practice of thinning fruit appears to have but little influence on the determination of fruit buds for the crop of the succeeding year. On the other hand the thinning of blossoms does affect the differentiation of fruit buds, as has been shown by Crow and later by Drain.

Secondary bloom is fairly common on some varieties during certain seasons. Such blossoms arise from the axils of leaves of the blossom cluster where there is usually a vegetative bud; apparently these buds are differentiated after the blossom bud begins to expand. The secondary blossoms commonly begin to open about the time the petals fall from the normal blossoms but they may appear a number of days later. Extensions of the fruit spurs arise from buds in the axils of leaves of the blossom cluster and normally make their appearance while the cluster is in bloom, apparently starting into growth about the time of the opening of the first flowers of the cluster.

The growth of spur extensions is of comparatively short duration, the exact length of time varying, possibly, with growing conditions. A period of fifteen days may be considered to be a long growing period for these growths, which develop in a normal manner. With spur growth completed, it is not unreasonable to assume that the initiation of buds has taken place. If this is true, then, unfavorable conditions for fruit-bud determination during this time may affect, seriously, the succeeding crop of fruit.

The nitrate-carbohydrate theory as propounded by Kraus and Kraybill throws a great deal of light on this subject in general but possibly in a more general way than is commonly accepted. For instance, this theory can scarcely account for spur growth of last year bearing two lateral blossom clusters and a terminal blossom cluster this year, and the latter also producing a vegetative growth and a secondary bloom. Such growths were fairly common on Rome in 1928. The more one ponders the subject of the causes of fruit-bud determination, the more one is attracted to the special formative material of Sachs.

Possibly, if this scientist were alive today, he would conclude that the balance between nitrates and carbohydrates is delicately adjusted at the time of fruit-bud differentiation and that one of a number of causes may operate to produce vegetative growth rather than fruit buds. Or, as suggested by Chandler, "it seems probable that fruit-bud formation may be promoted by the presence in the tissue of some particular substance, perhaps an organic nitrogenous

substance, or by some particular chemical composition or chemical environment of the protoplasm." Or, in other words, why may not some substance, comparable in its action to vitamins in animal development, be equally important in plants?

Of the various causes which may operate to upset this possibly, delicately adjusted balance, or to favor the production of a particular substance, it has appeared to the writers that light may be important. This conclusion has been reached after comparing the behavior of Ohio orchards with those of Colorado, where apple trees uniformly are more productive than they are in Ohio.

The principal difference in environment that comes to mind, other than the fact of altitude, is in the greater intensity, more effective hours of sunlight daily, and possibly, different quality of sunlight, that obtain in the orchard districts of that state. It is conceivable that a period of cloudy weather at the critical time may bring about a condition within the tree which will prevent fruit-bud differentiation. This possibility is also suggested by Chandler.

A simple experiment was begun in the spring of 1927 to test the effect of shade on fruit-bud formation. Twenty, twelve-year-old Rome trees were selected, all in a vigorous condition. As it was impracticable to inclose so many fairly large trees in tents, the expedient was adopted of covering from three to five of the lower limbs on the south side of each tree. Light weight muslin cloth was seected for the covering, each piece being about nine feet wide and welve feet long. The limbs were first drawn together with cord , hen the cover was placed over the limbs and fastened underneath , hus effectually shutting out all direct sunlight.

The tents were run in two series of ten trees each. In the first series the ten tents were put in place on the trees on the same date, May 2, just as the period of full bloom was coming on. The tent was allowed to remain on tree No. 1 for seven days, on tree No. 2 for 14 days, and so on throughout the series, a tent being removed approximately every seven days. By this arrangement the tent was in place on the last tree of the series from May 2 to July 12, a period of sixty days. In the second series the first tent was put on May 10, just as the blooming period was over, and was allowed to remain until July 19. This was a period of sixty-one days. The second tent was put in place on May 17 or seven days later and allowed to remain until July 19 as before, and so on throughout the series. By following this plan the last tent was in place from July 12 to 18, a period of seven days.

The blooming period for the season of 1928 was at its height on May 15, when results were apparent as follows: In series I, tree No. 1, where the tent was in place for one week beginning May 2, there was as much bloom under the tent as on an equal area outside.

Of the remaining nine trees, all of which were covered two weeks or more, beginning on May 2, five gave positive results, as there was no bloom on the shaded limbs while all of the trees bore, at least, a small amount of blossoms. Trees Nos. 3, 5, 8, and 9 were apparent ex-

ceptions as there was one blossom cluster borne under the tent on tree No. 3, twelve blossom clusters borne under the tent on No. 5 and four clusters under the tent on tree No. 9.

With trees number 3, 5, and 9 the exception proved to be apparent only as in each instance the blossoms were borne on second and belated growth of the spurs of the season of 1927. That is, after finishing their growth and setting terminal buds, each of these spur extensions made a distinct second growth which was terminated by a fruit bud. The evidence tends to indicate that these second growths were begun after the shade was removed which was July 19, in one instance. No other bloom that had been produced in this manner could be found on any other part of any of the trees with the exception of tree No. 1, series II, which is mentioned later. Not content to trust to their own judgment alone, the writers had their observations confirmed by Dr. J. Schaffner of the Department of Botany. Tree No. 8 presents more of a problem as its blossoms were normal, there being as many under the tent as outside. A possible explanation of this result may be that this tree was more advanced in development than the others when the tent was put in place. This condition is suggested by the fact that the tree is crowded by large plum trees on both the east and west sides. In two instances it happened that one-half of a branched limb in series I, was included within the tent. In both cases the half outside produced a normal amount of bloom, while that part under the tent was entirely barren. With all trees in series No. II, negative results only were produced; negative in that as much bloom was produced under the tents as out in each case. In this case the first tent was put in place on May 10, a week after the period of full bloom had passed. However, tree No. 1 deserves more than passing notice. Judging from the results with series I, this tree might easily have shown a similar response to shade. As it was, twelve of the blossom clusters were normal while nine were borne on distinct second growths of the season. These results may indicate that the spurs on this tree were in a more advanced stage of development when the shade was applied. These results may be a coincidence, to be sure, but if not, they tend to confirm the results in series I, viz., the inception of fruit-bud determination with these particular Rome trees, during the season of 1927, took place some time during a period of about two weeks, beginning with the period of full bloom.

The writers are well aware that they are reporting the results of tests of but one season, but they are certain that shading for a period of ten weeks, when begun just as the blossoming period was over, did not prevent blossom buds from forming, nor from opening in a normal manner the following spring. They also found that some spurs made a distinct second growth and set fruit buds which bloomed the following spring.

The Effect of Apple Blossom Removal on Flower Bud Formation

By John S. Bailey, *Massachusetts Agricultural College, Amherst, Mass.*

It has long been the aim of pomological investigators to induce biennially bearing trees to produce crops annually. Pruning, fruit thinning, fertilization, and various methods of soil management have all failed in practice to produce the desired results. From the work of Auchter (1) and others it is apparent that the time of fruit thinning is too late to affect blossom bud formation. The killing of the blossoms by frost usually results in the formation of flower buds for a crop the following year. Therefore, it seems possible that some method of thinning the blossoms might induce the formation of flower buds in the regular bearing year. Drain (2) used chemicals as a means of thinning, but in the work reported herein thinning was done by hand.

In 1924 six Wealthy and five Oldenburg trees were selected as representing the type of varieties which are markedly biennial bearers. The thinning was done May 14 and 15 when the blossoms were in the pink stage. All of the blossoms were removed from a spur, so that 50 per cent of the bloom removed means that 50 per cent of the spurs were completely deflorated. The per cent of the bloom in 1924 is that which the trees were carrying before the blossoms were removed. By per cent of bloom is meant, the estimated part of the total bloom that a tree could carry if it had a blossom cluster on every possible place—spur, terminal, or axillary—according to the variety, which could possibly carry such a cluster.

The Wealthy trees were thirteen years of age, only moderately vigorous, on Doucin stocks, and had fully settled into biennial bearing. They were located in a guard row between a cultivated and sod mulch plot where the soil was rather low in fertility. From two of them 50 per cent of the bloom was removed; from two more, 75 per cent; and from the remaining two, 100 per cent. The per cent of bloom for the next two years is given in Table I.

TABLE I—Bloom of Wealthy as Affected by Blossom Removal (Block H)

Tree	Per cent Bloom in 1924	Per cent Bloom Removed	Per cent Bloom in 1925	Per cent Bloom in 1926
A6	95	50	1	95
E6	95	50	1	85
D6	95	75	5	90
F6	95	75	1	90
B6	95	100	60	1
C6	95	100	70	1

The Oldenburg trees were in another orchard. They were in guard rows between two series of plots, one of which had cultivation with cover crops and the other was in sod and received 300 pounds of nitrate of soda to the acre. The trees were, therefore, all under the same treatment, located on soil rather low in fertility and conse-

quently only moderately vigorous, and had settled well into biennial bearing. One of them had 100 per cent of the bloom removal; two of them, 75 per cent; and two of them, 50 per cent. The bloom data for these is given in Table II.

TABLE II—BLOOM OF OLDENBURG AS AFFECTED BY BLOSSOM REMOVAL (BLOCK E)

Tree	Per cent Bloom in 1924	Per cent Bloom Removed	Per cent Bloom in 1925	Per cent Bloom in 1926
H9	90	50	1	70
J21	90	50	1	70
J9	90	75	15	60
J17	85	75	0	65
H5	85	100	65	85

It is striking that neither the removal of 50 per cent nor of 75 per cent of the bloom on the Wealthy trees caused the formation of flower buds for a crop of fruit in 1925. As was to be expected, the removal of all of the bloom merely changed the bearing year from the even to the odd years. With the Oldenburg trees the results are the same except that in one case, tree J9 from which 75 per cent of the bloom was removed, there was a 15 per cent bloom in 1925, which means enough for a light crop. It is unique that the Oldenburg tree from which all the blossoms were removed should have bloomed heavily the two succeeding years. Unfortunately this tree had to be cut down in 1926 because of crowding in the orchard so that its performance could not be followed longer.

Two Yellow Transparent trees which stood on a lawn and bloomed about 90 per cent in 1924 had 75 per cent of the bloom removed from one and 100 per cent from the other. The one from which 75 per cent of the bloom was removed in 1924 bore a good crop that year and had practically no bloom in 1925, while that from which all of the bloom was removed bloomed full in 1925. They have continued to alternate in blooming ever since. This observation corroborates the data given above for Wealthy and Oldenburg.

To check further on the effects of blossom removal on flower bud formation, 25 spurs from which the flowers had been removed were tagged on each of the Wealthy trees A6, F6, and C6, Table I, and on the Oldenburg trees H9, J17 and H5, Table II, from which in each case 50, 75 and 100 per cent of the bloom had been removed, respectively. About half of the tags were lost but, of those remaining, in no case was there a bloom cluster in 1925 on any spur in any tree unless all of the bloom had been removed from that tree in 1924. Of 14 tagged spurs remaining on Wealthy C6, from which all of the bloom had been removed, nine or 64 per cent bore blossom clusters in 1925; and of 14 tagged spurs on Oldenburg tree H5, from which all of the bloom had been removed, eight or 57 per cent bore blossom clusters in 1925. It is striking that although all of the bloom was removed from these two trees, not all of the spurs from which the blossoms were removed could be induced to form flower buds for 1925. This is shown also by the data in Tables I and II, for none of the trees from which all of the bloom was removed bloomed more than 70 per cent in 1925.

In 1926 three McIntosh trees were selected to see what effect blossom thinning might have on a variety which tends to bear annually. These trees were under a cultivation and cover crop type of soil management with no fertilizer added. They were young trees which had just come into good bearing but were only moderately vigorous, as the soil in which they grew was rather low in fertility. The L I tree had received a light pruning annually, the other two a moderate pruning; otherwise they had had similar treatment. They had 50, 75 and 100 per cent of their bloom removed, respectively. The results are given in Table III. The work was done May 11, 12, and 13 during the early pink stage of the bloom as was all of the work done in 1926.

TABLE III—BLOOM OF McINTOSH AS AFFECTED BY BLOSSOM REMOVAL (BLOCK K)

Tree	Per cent Bloom in 1926	Per cent Bloom Removed	Per cent Bloom in 1927	Per cent Bloom in 1928
F1	80	50	75	40
J1	90	75	50	70
L1	90	100	90	55

As a further test a large McIntosh tree which was 19 years old and in full bearing was selected. This tree was in an orchard which until 1924 had been in strip cultivation and since 1924 has been in a sweet clover sod. The orchard had had an annual application of nitrate of soda amounting to about 5 pounds per tree. The tree selected was, therefore, in a vigorous condition. It was carrying a 90 per cent bloom in 1926. From the west half of this tree all of the bloom was removed and from the east half two-thirds of the bloom. In 1927 this tree bloomed 60 per cent, the bloom being almost entirely on the west half. In 1928 it had a 40 per cent bloom, almost all of which was on the east half.

For comparison with the McIntosh trees and as a check on the previous work, two Wealthy trees were selected. They were under a sod mulch type of soil management with an application of 200 pounds per acre of sulphate of potash and 300 pounds of acid phosphate and were only moderately vigorous. The data is given in Table IV.

TABLE IV—BLOOM OF WEALTHY AS AFFECTED BY BLOSSOM REMOVAL (BLOCK F)

Tree	Per cent Bloom in 1926	Per cent Bloom Removed	Per cent Bloom in 1927	Per cent Bloom in 1928
A3	90	67	5	70
C1	85	100	60	10

The results with McIntosh are not so clear cut as with the other three varieties but there is a tendency in the same direction. Removing all of the bloom changed the year of the heavier crop from the even to the odd year but did not result in a biennially bearing tree. Removing 75 per cent of the bloom did not change the year of the heavier crop, but the removal of 50 per cent of the bloom did. The latter was contrary to expectations and although it is probably

only one of those irregularities which occur in most experiments, it may indicate that blossom thinning will affect annually bearing trees differently than biennially bearing trees. However, the results with the McIntosh tree which had the east half and west half treated differently fall in line with the general trend of results with the other varieties, for the removal of all the bloom changed the heavy bearing year on the west side of the tree, while removing two-thirds of the bloom did not affect noticably the east side.

The results with Wealthy in 1926 substantiate those obtained with Wealthy, Oldenburg, and Yellow Transparent in 1924, for here again only the tree from which all the bloom was removed formed flower buds for a crop the succeeding year and not a full bloom was obtained even then.

If the trees used in this experiment had been growing more vigorously, it is possible that they would have responded differently to the treatment they received. Also there is a possibility that somewhere between the removal of 75 and 100 per cent of the bloom there may be a per cent where a fair crop will be borne and yet flower buds formed for the next year. These points remain to be ascertained by further investigation. The results strongly indicate that, if the entire tree is considered as a unit, annual crops will not be obtained by blossom thinning from trees which normally bear biennially.

Literature Cited

(1) Auchter, E. C. Five years' investigations in apple thinning. W. Va. Agr. Exp. Sta. Bul. 162. 1917.
(2) Drain, B. D. Annual crops from biennial bearing apple trees. Proc. Amer. Soc. Hort. Sci., 21:300–302. 1924.

Nutritional Studies with the Strawberry

By W. E. Whitehouse, *University of Maryland, College Park, Md.*

NUTRITIONAL studies with the strawberry have been conducted at the University of Maryland since 1924. This paper presents some of the results obtained to date. In 1924 and 1925, a preliminary study was made preparatory to conducting experimental work under field conditions with the Howard 17 (Premier) strawberry. Plants were grown in quartz sand in the greenhouse under varying nutritional conditions in an effort to vary their growth and blossoming in a manner similar to that of Kraus and Kraybill (2) in studying the tomato plant. Chemical analyses of these strawberry plants were made at intervals throughout their growth in order that differences in growth and blossoming might be studied with relation to the chemical composition of the plant at the time these differences occurred.

On March 1, 1924, and 1925, Howard 17 (Premier) runner plants of comparable vigor and size were selected and planted in wooden greenhouse benches supplied with bottom heat and filled with quartz sand. The benches were divided into four plots, each one containing ninety plants. The first received a complete nutrient solution, which Kraus had found favorable to the normal growth and fruiting of the tomato plant in sand; the second received the same solution

with the exception that the amount of nitrogen was doubled; the third received the same solution with the exception that the nitrogen was omitted; and the fourth was left untreated as a check. Plots were watered with tap water. The nutrients were applied at two- to three-week intervals from April 1 to May 22 and at monthly intervals from then until August 3. The plants were allowed to grow until cold weather, the ventilators opened, growth checked, and the plants rendered inactive until the following February, at which time heat was turned on. A blossoming record was made of each plant. It is impossible to present complete data on growth and chemical analyses at this time and keep within the limits set for papers of this Society. Accordingly, in most instances, only a general discussion of results will be given.

Results of Growth Studies

Growth records are presented in Table I. Plants which received a complete nutrient solution, in which the nitrogen was doubled, produced more runners, longer leaf petioles, a larger number of leaves, and developed more crowns on the average than the plants which received a complete nutrient solution. These plants were highly vegetative. The growth of the plants receiving a complete nutrient solution, although less vigorous, had the appearance of well grown fruitful plants. The leaves on both of these plots had a dark green healthy color. A decided lack of vegetative growth by the plants receiving a nutrient solution minus nitrogen and those left untreated was evidenced in the short weak leaf petioles, fewer leaves, and fewer crowns, and the fact that no runners were developed. The average dry weight of the plants receiving a nutrient solution minus nitrogen and those left untreated was one-half to one-third the amount of the plants which received a complete nutrient solution.

About three weeks after planting, the leaves first formed on the plants receiving no nitrogen turned red or light yellow at the margin, this color spreading over the entire leaf in a short time, followed by the death of the leaf. Each new leaf acted more or less in a similar manner so that although the plants on these plots produced a total number of leaves more or less comparable to the number produced on the plot receiving a complete nutrient solution, the number of leaves retained was much less than the number grown and retained throughout the season by the plants receiving a complete nutrient solution. Wallace (5) and Davis and Hill (1) have observed some of these symptoms occurring on strawberry plants grown in a somewhat similar type of sand, where nitrogen was a limiting factor.

In later experiments at Maryland one lot of plants in quartz sand was treated with a nutrient solution minus phosphorus and potassium, and a second lot with a complete nutrient solution. The plants which received no phosphorus or potassium made a strong, healthy growth. However, the plants which received these elements in addition to nitrogen made a more vigorous growth as evidenced by broader, thicker leaflets and petioles. The data on this experiment are not presented at this time. Loree (3) and Wallace (5) obtained somewhat similar results.

TABLE I—GROWTH OF HOWARD 17 (PREMIER) STRAWBERRY PLANTS IN QUARTZ SAND UNDER VARYING NUTRITIONAL CONDITIONS

Treatment*	Average No. of Runners Per Plant		Average Leaf Petiole Length (Inches)		Average No. of Leaves Per Plant		Average No. of Crowns Per Plant		Average Dry Weight					
									Sept. 24th, 1924			Sept. 26th, 1925		
	1924	1925	1924	1925	1924	1925	1924	1925	Tops	Roots	T/R	Tops	Roots	T/R
++N	4.65	10	8	6	35.45	24.35	2.5	1.65	8.82	1.68	5.25	8.68	1.64	5.29
+N	3.7	4.2	5.5	4.2	21.80	23.62	1.95	1.55	8.91	1.99	4.47	—	2.17	—
—N	0	0	2	2	20.10	20.44	1.75	1.55	4.51	2.31	1.95	2.58	1.06	2.43
Check	0	0	2	2	20.70	17.55	1.68	1.51	3.27	1.81	1.86	2.44	1.46	1.67

*++N Complete nutrient solution with high nitrogen content.
+N Complete nutrient solution.
—N Nutrient solution minus nitrogen.

On plots where the supply of nitrogen was limited, a plant with a relatively heavy root system and light weak top resulted, as shown by the top-root ratio in Table I as based on dry weight. The plants developed a very fine extensive root system and a small crown. Tops show first effects from lack of nitrogen. When nitrogen was not lacking the plants developed a relatively heavy top as compared to root system and the crowns were larger. Loree (3) found this same relation of top and root development in his study of the Dunlap strawberry.

Results of Blossom Studies

Samples were taken every week for a study of the time of fruit bud differentiation in the different plots. The crowns of the plants sampled were placed in fixing solution and run up into paraffin for sectioning by the usual paraffin method. The initial stage of fruit bud differentiation did not appear in all the plants taken at any one sampling, some showing signs of differentiation while others from the same plot did not. Evidence of fruit bud differention in some of the plants was found in all plots between August 3 and August 13. Ruef and Richey (4) found a variation in the time of fruit bud differentiation occurring under varying nutritional conditions.

The blossoming record of each plot is given in Table II. The highly vegetative plants receiving a complete nutrient solution with double nitrogen content had less than ⅔ as many blossom clusters and less than ⅓ as many blossoms per plant as the moderately vegetative plants which received a complete nutrient solution containing less nitrogen. The weakly vegetative plants on the plot which received a nutrient solution minus nitrogen produced approximately the same number of blossom clusters and blossoms as those plants receiving a complete nutrient solution with double nitrogen. The check plot produced very few blossoms as compared to the other plots.

Results of Chemical Studies

Samples of the plants from each plot were taken at intervals throughout their growth for chemical analysis. A part of the chemical analyses is presented in Table II. On all dates of sampling relatively large differences of total carbohydrate, starch, and soluble and total nitrogen contents were found in both the tops and the roots of the plants among the different treatments. Likewise large differences are shown in the starch-nitrogen and the carbohydrate-nitrogen ratios. The relatively high soluble nitrogen in the plants treated with nitrogen as compared to those plants not treated with nitrogen is of interest. The plants receiving a complete nutrient solution with double nitrogen had a relatively high nitrogen and low carbohydrate content on all dates sampled, particularly so if starch alone is considered rather than the total carbohydrate content. The plants receiving a moderate supply of nitrogen showed a smaller amount of nitrogen and in most instances a larger amount of starch present, than in those plants receiving double amounts of nitrogen.

A comparison of the clusters and blossoms formed by the plants in the two nitrogen plots shows that a larger number of blossom clusters

TABLE II—NITROGEN AND CARBOHYDRATE CONTENT AND BLOSSOMING RECORD OF HOWARD 17 (PREMIER) STRAWBERRY PLANTS GROWN IN QUARTZ SAND UNDER VARYING NUTRITIONAL CONDITIONS

Date	Treatment*	Per cent Total Nitrogen		Per cent Alcohol Soluble Nitrogen		Per cent Starch		Per cent Total Carbohydrates		Starch-Nitrogen Ratio		Total Carbohydrate-Nitrogen Ratio		Average Number Blossoms Clusters per Plant	Average Number Blossoms per Cluster	Average Number Blossoms per Plant
		Top	Roots	Top	Roots	Top	Roots	Top	Roots	Top	Roots	Top	Roots			
June 30 1924	++N	2.17	1.65	0.33	—	4.18	3.55	36.41	19.70	1.93	2.15	16.78	11.94	1.01	4.17	4.21
	+N	1.31	1.15	0.19	0.14	6.21	9.37	24.83	23.01	4.75	8.14	18.97	20.00	2.80	4.43	12.40
	—N	0.88	0.72	0.17	—	15.42	13.81	24.95	33.58	17.50	19.18	28.18	46.70	1.45	3.80	5.57
	Check	0.82	0.81	0.13	0.09	11.93	18.56	22.57	32.59	14.54	22.91	27.51	40.30	1.22	3.33	4.06
Aug. 15 1924	++N	1.31	2.67	0.26	0.09	7.13	7.38	26.40	27.97	5.44	2.82	20.15	10.46			
	+N	0.85	1.88	0.16	—	7.60	10.80	26.90	33.88	8.94	5.74	31.65	18.04			
	—N	0.97	1.16	0.10	—	13.32	16.60	25.47	25.67	13.74	14.32	26.25	22.12			
	Check	1.03	1.32	0.12	—	15.22	14.85	27.28	21.63	14.69	11.25	26.47	16.38			
Sept. 24 1924	++N	1.71	1.42	0.25	—	6.83	11.98	32.23	26.51	3.99	8.44	18.94	18.66			
	+N	1.66	1.11	0.22	—	12.37	17.82	33.85	31.41	7.44	16.05	20.39	28.30			
	—N	1.13	0.88	0.18	—	10.00	25.98	36.52	36.49	8.84	29.49	32.30	41.40			
	Check	0.94	0.62	0.12	—	12.92	11.15	36.97	31.03	13.76	17.98	39.33	50.02			
Aug. 8 1925	++N	2.04	1.23	0.24	0.24	6.94	3.26	21.14	21.20	3.40	2.65	10.36	17.45	2.03	2.80	5.68
	+N	1.46	1.09	0.11	0.14	11.52	4.60	27.59	21.34	7.88	4.21	18.88	19.59	3.50	4.90	17.15
	—N	1.07	0.80	0.05	0.08	14.34	5.29	25.61	25.65	13.41	6.62	23.95	32.05	1.45	3.40	5.85
	Check	0.89	0.82	0.009	0.05	20.02	6.93	28.26	22.82	22.48	8.44	31.72	27.85	1.07	3.30	3.52
Aug. 27 1925	++N	1.93	1.45	0.33	0.19	6.81	4.27	22.92	20.86	3.52	2.94	11.89	14.36			
	+N	1.61	1.30	0.20	0.15	10.06	3.60	22.84	17.38	6.21	2.77	14.23	13.37			
	—N	1.06	0.81	0.12	0.09	12.07	5.33	22.26	22.84	11.39	6.58	24.77	28.18			
	Check	0.99	1.02	0.10	0.09	12.87	5.00	26.46	21.70	13.00	4.90	26.71	21.25			
Sept. 26 1925	++N	1.72	1.33	0.21	0.17	9.05	5.21	24.55	22.28	5.29	3.92	14.27	16.75			
	+N	—	1.04	—	0.15	—	5.86	—	21.90	—	5.64	—	21.45			
	—N	1.22	0.93	0.16	0.13	11.81	6.30	26.94	20.96	9.68	6.78	22.08	22.50			
	Check	0.99	0.73	0.14	0.14	13.06	7.36	28.20	22.00	13.18	10.08	28.50	30.13			

*++N Complete nutrient soluton with high nitrogen content.
+N Complete nutrient solution.
—N Nutrient solution minus nitrogen.

On plots where the supply of nitrogen was limited, a plant with a relatively heavy root system and light weak top resulted, as shown by the top-root ratio in Table I as based on dry weight. The plants developed a very fine extensive root system and a small crown. Tops show first effects from lack of nitrogen. When nitrogen was not lacking the plants developed a relatively heavy top as compared to root system and the crowns were larger. Loree (3) found this same relation of top and root development in his study of the Dunlap strawberry.

Results of Blossom Studies

Samples were taken every week for a study of the time of fruit bud differentiation in the different plots. The crowns of the plants sampled were placed in fixing solution and run up into paraffin for sectioning by the usual paraffin method. The initial stage of fruit bud differentiation did not appear in all the plants taken at any one sampling, some showing signs of differentiation while others from the same plot did not. Evidence of fruit bud differention in some of the plants was found in all plots between August 3 and August 13. Ruef and Richey (4) found a variation in the time of fruit bud differentiation occurring under varying nutritional conditions.

The blossoming record of each plot is given in Table II. The highly vegetative plants receiving a complete nutrient solution with double nitrogen content had less than ⅔ as many blossom clusters and less than ⅓ as many blossoms per plant as the moderately vegetative plants which received a complete nutrient solution containing less nitrogen. The weakly vegetative plants on the plot which received a nutrient solution minus nitrogen produced approximately the same number of blossom clusters and blossoms as those plants receiving a complete nutrient solution with double nitrogen. The check plot produced very few blossoms as compared to the other plots.

Results of Chemical Studies

Samples of the plants from each plot were taken at intervals throughout their growth for chemical analysis. A part of the chemical analyses is presented in Table II. On all dates of sampling relatively large differences of total carbohydrate, starch, and soluble and total nitrogen contents were found in both the tops and the roots of the plants among the different treatments. Likewise large differences are shown in the starch-nitrogen and the carbohydrate-nitrogen ratios. The relatively high soluble nitrogen in the plants treated with nitrogen as compared to those plants not treated with nitrogen is of interest. The plants receiving a complete nutrient solution with double nitrogen had a relatively high nitrogen and low carbohydrate content on all dates sampled, particularly so if starch alone is considered rather than the total carbohydrate content. The plants receiving a moderate supply of nitrogen showed a smaller amount of nitrogen and in most instances a larger amount of starch present, than in those plants receiving double amounts of nitrogen.

A comparison of the clusters and blossoms formed by the plants in the two nitrogen plots shows that a larger number of blossom clusters

The Influence of Position of Buds on the Development of Clusters of Muscat of Alexandria and Molinera

By A. J. Winkler, *University of California, Davis, California*

THE improvement in the fruiting of certain varieties of *Vitis vinifera*, especially Muscat of Alexandria, following cane pruning with the removal of flower clusters to control crop, has raised the question in the minds of some workers as to whether or not the development of fruit from buds on the canes with this method as opposed to the development of fruit from buds on spurs with usual pruning, is not responsible for much of the improvement rather than the reasons advanced by the author in previous papers. (See the 1927 report and references.)

Although some figures were collected relative to the influence of position of bud on fruiting in 1925, many additional measurements on better controlled tests were made during the past season. This paper presents the data for Muscat and Molinera, varieties which usually yield commercial tonnages of fruit with spur pruning, but the fruit of which is very much improved by cane pruning with flower cluster thinning.

In 1925, a lot of 96 vines of Muscat was divided into 12 plots of 8 vines each. All the vines were cane pruned. In controlling the crop by flower cluster removals, clusters were retained only at the bases of the canes on 6 plots and only at the ends of the canes on the other plots. The influence of this treatment on crop, weight of cluster and berry, and percentage of normal berries is given in Table I.

During the past season, several plots of 10 vines each of Muscat were cane pruned. In one plot all buds but four at the base of each cane were removed, in another four buds were retained in the middle of the cane; while in a third, four buds were retained at the ends of canes. The bud removals were made before growth started. All the clusters developing from the shoot arising from the retained buds on the canes were allowed to develop. The influence of position of bud as indicated by this treatment on crop, weight and length of cluster, percentage of normal berries, and weight of berry is also given in Table I.

An observation of practice to which many viticulturists would adhere strongly, namely, that the mid-portion produces the best, the basal portion the next best, and the end portion of the canes the poorest fruit, is suggested by the figures of Table I. There is, however, no significant difference in favor of any position represented by these treatments and measurements. The figures show that for the Muscat, position of bud has little or no influence on the development of the cluster.

This season, two lots of 56 vines of Muscat and Molinera were divided into plots of seven vines each. All plots were cane pruned. The flower clusters on the vines of one-half of the plots of each variety were thinned, while the vines of the other plots were allowed to mature

TABLE I—THE INFLUENCE OF POSITION OF BUDS ON THE FRUITING OF MUSCAT

Year	Position of the Buds	Crop to a Vine (Kilos)	Weight of Cluster (Grams)	Length of Cluster (Cm.)	Per cent of Normal Berries	Weight of Berry (Grams)
1925	At base of canes	5.2± .59	346±18.2	———	94	4.1 ±.04
	At end of canes	5.1± .57	274± 9.4	———	92	3.8 ±.03
1928	At base of canes	9.8± .57	253±14.0	22.0±.54	86	3.39±.06
	At middle of canes	10.4±1.14	265±14.1	22.6±.53	85	3.08±.05
	At end of canes	7.4±1.14	243±15.1	20.8±.67	85	3.29±.04

TABLE II—THE LENGTH AND WEIGHT OF CLUSTER ON SHOOTS ARISING FROM BUDS ONE TO TEN ON THE CANES

Variety	Type of Pruning	Buds on the Canes									
		1	2	3	4	5	6	7	8	9	10
		Length of cluster in centimeters									
Muscat	Cane*	28.3±1.1	28.3±1.1	28.0±1.7	28.3±.94	30.1±.80	29.6±7.4	30.3±.26	28.5±.53	28.0±1.5	27.8±1.3
	Cane	18.4± .8	17.8±.97	18.4±.94	20.0±.80	20.4±.87	19.4±.87	20.8±.80	21.2±.67	19.8±.87	19.9±.74
	Spur		19.1±.81								
Molin-era	Cane*	25.6±.65	27.6±.74	29.4±.60	30.1±.87	28.2±1.0	27.9±1.1	30.2±1.1	29.4±1.0	29.7±1.0	29.6±.74
	Cane	21.4±1.2	21.4±.94	22.6±1.0	23.3±.47	22.3±.67	23.5±.87	22.3±.80	21.6±1.1	24.4±7.4	22.9±.67
	Spur		20.2±.72								
		Weight of Cluster in Grams									
Muscat	Cane*	414±35	430±20	462±31	444±24	398±22	520±20	587±32	366±18	590±31	448±20
	Cane	159±20	170±22	195±16	186±18	217±12	195±12	181±15	226±12	204±13	204±23
	Spur		201±19								
Molin-era	Cane*	453±27	515±21	653±21	663±36	554±28	657±33	540±26	490±25	567±20	608±22
	Cane	421±49	421±49	535±45	543±49	475±23	508±41	498±41	430±41	458±32	425±31
	Spur		455±37								

*Crop controlled by the removal of flower clusters before blooming.

all of the clusters that set. At the time of harvesting, all of the clusters on the flower cluster thinned vines and the basal clusters on each shoot of the other vines were weighed and the length determined. These figures together with average weight and length measurements of clusters from spur pruned vines are shown in Table II.

The figures of Table II show conclusively that, within the range of these tests, position of bud does not influence the development of Muscat and Molinera clusters. The finding of lighter clusters at buds 1 and 2 is in agreement with the available *a proiri* information. Statistical treatment, however, indicates that the recorded reduction in the weight of these clusters is not significant. The highest coefficient of correlation between position of bud and length or weight of cluster prevailing for the various measurements of Table II is 0.1609 ± .051.

Under the same treatment, there is no significant difference between the weights or lengths of clusters at any position on the canes. Again, where all of the clusters that set were allowed to develop, there is no difference in the weight and length of clusters born on two or three bud spurs or at various positions on canes.

On the contrary, there is a great difference in the weight and length of Muscat clusters at all positions on the canes between vines where the crop was controlled by flower cluster thinning and the vines on which all clusters were allowed to mature. A similar, although smaller difference is shown for these treatments with the Molinera.

Conclusions

1. The position of bud, other conditions being equal, does not influence the development of clusters of Muscat and Molinera.

2. The data confirm my previous statements that the improvement in fruiting of these varieties following cane pruning with flower cluster thinning, to control crop, is the result of a better nutrition of the flower part at and just prior to blooming.

Note: With varieties the fruiting habit of which makes half-long or cane pruning necessary results quite contrary to the above might be expected. Such varieties did not come within the scope of these tests.

Growth and Fruit Production Studies in the Grape

By A. S. Colby and L. R. Tucker, *University of Illinois, Urbana, Illinois.*

THIS paper deals with the fruiting habit of the grape and some of the relations of fruiting to shoot growth. It has been shown that Concord canes of average internodal length and average "pencil size" in diameter are most fruitful (Partridge, 1922). Of these canes, those of medium length are most productive (Schrader, 1923). The basal end of the cane has been found to be least fruitful (Keffer, 1906; Schrader, 1923; Partridge, 1925; Swartwout, 1925).

Although the above studies have brought out certain main features of the fruiting habit of the grape, it seemed desirable to check some phases further under Illinois conditions. To this end the studies reported here have dealt specifically with three main points, namely, cluster growth and yield, shoot growth and its relation to yield, and the factors affecting size in both cluster and berry.

In gathering data on these points, shoots on 12 Concord vines trained to the Kniffin system were classified according to the number, size, and arrangement of clusters they produced in 1926. In a similar study, using 11 vines of Moore Early in 1927 and 10 vines in 1928,* length and diameter measurements were included. These measurements were used as an indication of vegetative growth. The results of the 1928 data confirm those of 1927; consequently, in this report the data for 1927 only are included. Although the Concord records were taken in 1926, and those of Moore Early in 1927, the seasonal conditions affecting growth were sufficiently similar so that the results can be considered comparable.

Cluster Growth and Yield

The grape cluster has been studied from a number of angles. The summaries presented in Table I show that the number of clusters included is relatively large and the data therefore may be taken as a fairly accurate index of the fruiting pattern in these varieties.

Concord clusters ranging up to 4 per shoot and averaging 2.13 ounces are larger than Moore Early, which have only a few shoots producing a maximum of three clusters each, with an average size of 1.55 ounces. As more clusters are formed per shoot on the Concord, their average size becomes larger, but the data do not show conclusively a similar characteristic of Moore Early.

The tip cluster on the shoot becomes more distal as more are set, showing it to be the extra cluster formed. The nutritional condition causing clusters to develop at the more distal nodes also increases the size of the others (Table I). As a result, although the tip clusters remain small the largest clusters are formed near the base of the shoots which produce the greatest number.

*In 1928 one vine had been injured and appeared to be dying: therefore, it was not used.

TABLE I—A SUMMARY OF THE MEASUREMENTS ON THE FRUITING HABIT OF THE GRAPE
(The clusters are numbered from the base to tip of the shoot.)

Concord in 1926

Range in Number of Clusters per Shoot	Shoots Grouped According to Number of Clusters Borne	Average Weight of Clusters According to Location on the Shoot				Weight of Fruit per Shoot in Ounces	Weight of Fruit per Cluster in Ounces
		First	Second	Third	Fourth		
0	10					0	
1	79	2.41±.12				2.41	2.41
2	215	4.34±.07	3.20±.07			7.54	3.77
3	149	5.08±.09	4.44±.08	2.72±.07		12.24	4.08
4	5	4.6	5.4	5.0	3.0	18.0	4.5
Total	458	1903.41	1376.56	430.28	3.0		
Aver. weight of clusters in order borne		4.25	3.73	2.79	3.0	8.13	3.82

Moore Early in 1927

Range in Number of Clusters per Shoot	Shoots Grouped According to Number of Clusters Borne	First	Second	Third	Fourth	Weight of Fruit per Shoot in Ounces	Weight of Fruit per Cluster in Ounces
0	55					0	
1	123	1.73±.07				1.73	1.73
2	249	2.93±.05	2.28±.05			5.21	2.60
3	28	3.20±.15	2.77±.12	1.46±.10		7.43	2.48
Total	455	1031.96	645.28	40.88			
Aver. weight of clusters in order borne		2.58	2.33	1.46		3.78	2.44

Fruit production on the Concord and Moore Early is heaviest at the second or third nodes on the shoot, gradually decreasing to no fruit at about the seventh node. According to chemical studies made by Schrader (1926), reducing sugars are low in this area and the nitrogen content increases as fruit production in these nodes decreases.

It will be seen, therefore, that in Illinois as in Michigan, Missouri, and Maryland, the largest yield per shoot is obtained when the cluster number is largest. Also, at least in Illinois, the clusters decrease in size from the base to the tip, in the fruiting zone of the shoot.

SHOOT GROWTH AND ITS RELATION TO YIELD

Shoot length was considered to be largely a measure of primary growth, and diameter (measured between the 3d and 4th nodes) of secondary thickening. Although the diameter measurements do not show the relative amounts of secondary growth as would cross-sectional areas, Table II indicates a direct relation between primary growth and secondary thickening. The diameter range divides the short shoots into relatively more refined groups as to vigor than does the length classification and places the long shoots in relatively larger groups.

The relation between length and fruiting in Moore Early (Table III), shows that shoots between 15 and 50 inches long are most fruitful. Also, shoots producing little or no fruit average slightly less in length than those which yield more. Medium length shoots not only yield highest, but vary to a greater degree in production, while low yielding shoots vary most in length. Shoot diameters (Table IV) indicate a similar relation between vigor and fruiting to that shown by length, when the differences between the measures of vigor are kept in mind.

Therefore, shoots of medium vigor in both length and diameter are most fruitful, and, according to Partridge (1922) and Schrader (1923), make the most productive canes. This relation between medium vigor and yield correlates with the findings presented by Kraus and Kraybill (1918) in the tomato in that conditions favorable for moderate growth are also favorable for maximum fruit production.

THE FACTORS AFFECTING SIZE IN BOTH CLUSTER AND BERRY

In selecting material for this study, 100 Concord clusters were taken from pickers' baskets. The weight of stem and the number and weight of berries was determined for each cluster. The average number of berries was 38 per cluster. The fruit almost completely determines the weight of cluster because the stem weight is but 1 to 6 per cent of the total weight.

In a study of relationships, it was found that the correlation between the number of berries and weight of cluster was $+ .619 \pm .042$, while between the average size of berries and weight of cluster, the correlation was only $+ .381 \pm .058$. These correlations show that the weight of the cluster is determined primarily by the number

TABLE II—Relation Between Length and Diameter of Shoot in Moore Early in 1927

Classes in Shoot Diameter in Cm.	Classes in Shoot Length in Inches											Total Number of Shoots	Average Length in Inches
	5.5	15.5	25.5	35.5	45.5	55.5	65.5	75.5	85.5	95.5	105.5		
.145	5											5	5.5
.245	36											36	5.5
.345	40	24	3									67	10.2
.445	7	83	21	3	1							115	17.5
.545	1	30	59	25	18	6	4	1	1			145	30.6
.645		3	18	25	11	5	2	2				66	37.2
.745			2	1	2	5	1	1	4			16	58.6
.845								1	2		1	4	88.
Total No. of shoots	89	140	103	54	32	16	7	5	7	0	1	454	
Aver. dia. per shoot in cm.	.303	.454	.540	.589	.589	.633		.735					

TABLE III—Relation Between Length and Fruiting of Shoot in Moore Early in 1927

Fruit Weight per Shoot in Ounces	Classes in Shoot Length in Inches											Total Number of Shoots	Average Length in Inches
	5.5	15.5	25.5	35.5	45.5	55.5	65.5	75.5	85.5	95.5	105.5		
0	23	11	8	1	2	2	2	1	4		1	55	25.3
½–2	44	31	14	6	4	5	2	2	2			110	20.1
2½–4	17	35	18	13	9	3		1				96	23.0
4½–6	2	38	25	13	7	4	3		1			93	27.1
6½–8	2	17	28	12	8	1						68	26.9
8½–10	1	8	8	7	2	1		1				28	28.7
10½–12			2	2								4	30.5
Total No. of shoots	89	140	103	54	32	16	7	5	7		1	454	
Aver. wt. per shoot in ounces	1.6	4.0	4.9	5.4	4.6	3.4	2.7	2.8	0.9		0.0		

TABLE IV—RELATION BETWEEN DIAMETER AND FRUTING OF SHOOT IN MOORE EARLY IN 1927

Fruit Weight per Shoot in Ounces	Classes in Shoot Diameter in Cm.								Total Number of Shoots	Average Diameter in Centimeters
	.145	.245	.345	.445	.545	.645	.745	.845		
0	2	11	11	12	7	6	3	3	55	.45
½–2	3	20	30	25	21	10	2		111	.42
2½–4		4	15	26	34	14	3		96	.50
4½–6			7	33	33	14	6		93	.52
6½–8		1	4	13	34	14	2		68	.54
8½–10				7	13	7		1	28	.56
10½–12					3	1			4	.57
Total No. of shoots	5	36	67	116	145	66	16	4	455	
Aver. wt. per shoot in ounces	0.6	1.2	2.3	3.8	5.0	4.6	3.6	2.2		

TABLE V—SUMMARY OF NUMBER OF SEEDS AND SIZE OF GRAPE BERRIES IN 1928

Variety	Weight of Berry in Grams		Number of Seeds		Correlation Between Berry Size and Seed Number	Number of berries
	Average	Std. Dev.	Average	Std. Dev.		
Agawam	$3.76 \pm .045$	0.97	$2.26 \pm .067$	0.996	$+.638 \pm .040$	100
Concord	$2.88 \pm .042$	0.62	$2.29 \pm .045$	0.670	$+.619 \pm .042$	100
Moore Early	$3.04 \pm .027$	0.75	$2.27 \pm .029$	0.803	$+.625 \pm .022$	352

of berries set and to a less extent by their size. When large clusters are formed the nutritional condition is such that both the number and size of berries are increased. The correlations indicate that the conditions bringing about an increase in number of berries on the cluster cause them to grow larger. However, the correlation of $+ .160 \pm .066$ for the 100 clusters shows very little relation between the number of berries on the cluster and their average size.

In order to remove the effect of the third factor upon the other two, partial correlations as computed by the method given by Wallace and Snedecor (1925) were calculated from the above three correlations. The correlation between number of berries and weight of cluster after the effect of size of berry is removed is $+ .573 \pm .045$, indicating very little change due to the size of berry. When the effect of number is removed from the second relation, the correlation between size of berries and weight of cluster of $+ .883 \pm .015$ is higher. This shows that the conditions affecting size of berry materially change the size of cluster when the number of berries is held constant. The correlation between number and size of berries with the effect of weight of cluster removed is $— .090 \pm .067$. Number alone did not increase the size of individual berries, contrary to previous indications.

However, this correlation does not show an appreciable decrease in size of berry as their number increases, as is generally conceded to be the case in other fruits. It should be kept in mind that the increase in number of berries per cluster in this case is not necessarily due to a larger per cent set, because more flowers may have been formed in some clusters than in others. Nutritional conditions favoring the formation of flowers may also affect their development, thereby holding a natural balance of normal growth. This, of course, is a different situation than that caused in the plant by thinning of fruits where the balance is shifted by the removal of flowers or fruits. The factors which bring about an increase in size of cluster do so first and to the greatest extent, by increasing the number of berries and then, by producing larger ones.

The number of seeds and weight of individual berries are very consistent in the Concord, Moore Early, and Agawam, and the number studied is large enough to make the results significant (Table V). Most of the berries vary in size about 75 per cent of the average, as measured by the standard deviation. The correlation between number of seeds and size of berry, $+ .6$, shows that size is partially determined by the number of seeds formed, as is generally conceded to be the case with many fruits. This indicates that pollination and fertilization are important in these varieties. Some other factor, or group of factors, probably due to nutrition after the berries are set, also plays an important part, or the correlation would be higher.

SUMMARY

1. The largest clusters are formed (in Concord and Moore Early) on shoots producing the larger number of clusters.
2. Clusters increase in weight on the shoot from the tip toward the base of the fruiting zone.

3. In Moore Early, shoots of medium vegetative vigor are most productive, while both weak and very vegetative shoots are less productive.

4. The size of the cluster in Concord is determined both by the number and size of berries produced.

5. The size of berries in Concord, Moore Early, and Agawam is partially determined by the number of seeds formed and partially by internal conditions after the number of seeds is determined.

Literature Cited

1. Keffer, C. A. The fruiting habit of the grape. Tenn. Agr. Exp. Sta. Bul. 77. 1906.
2. Kraus, E. J., and Kraybill, H. R. Vegetation and reproduction with special reference to the tomato. Ore. Agr. Exp. Sta. Bul. 149. 1918.
3. Partridge, N. L. Further observations on the fruiting habit of the Concord grape. Proc. Am. Soc. Hort. Sci., 19:180–183. 1922.
4. ———. The fruiting habits and pruning of the Concord grape. Mich. Agr. Exp. Sta. Tech. Bul. 69. 1925.
5. Schrader, A. L. Growth studies of the Concord grape. Proc. Am. Soc. Hort. Sci., 20:116–122. 1923.
6. ———. The Concord grape. Pruning and chemical studies in relation to the fruiting habits of the vine. Md. Agr. Exp. Sta. Bul. 286. 1926.
7. Swartwout, H. G. Fruiting habits of the grape. Proc. Am. Soc. Hort. Sci., 22:70–74. 1925.
8. Wallace, H. A., and Snedecor, G. W. Correlation and machine calculation. Iowa State College Official Publication, 23: No. 35:5–47. 1925.

Pruning and Fruiting Studies of the Concord Grape

By A. LEE SCHRADER, *University of Maryland, College Park, Md.*

IN a paper (1) presented before this society in 1923, the writer presented some preliminary data on the pruning of young Concord vines and the production of a full crop in the third season after planting. Further yield data for the two following seasons were given in Maryland Experiment Station Bulletin 286, 1926. The conclusion was drawn that Concord grape vines can be brought into full bearing by the third season and will continue to bear large crops in following seasons. The yield records of three more seasons can now be added to give further evidence on this point. The complete data to date are presented in Table I.

A brief review of the methods of pruning used will help to explain the table. All vines were pruned at planting (1921) to 2 buds according to the usual practice. In method I, the vines were cut back again to 2 buds at the end of the first season but only the more vigorously growing shoot was allowed to develop in the second season. Sucker growth was removed as it appeared. Lateral shoots which grew in the second season were used as fruiting canes in the third season (1923), as indicated in the table. In method II, a single cane was brought to the top wire of the trellis at the end of the first season and all other canes were removed. The buds below the lower wire were removed and shoots were kept removed from this portion of the trunk. The shoots which developed above the lower wire were used as fruiting canes in the third season. In method III, a single cane was brought to the lower wire of the trellis at the end of the first season. All sucker growth was removed as it appeared during the second season and only four or five upper buds were retained. The trunk was extended to the top wire at the end of the second season by using one of the canes developed in the second season.

The yield data given in Table I show that all vines have yielded an average of approximately five tons to the acre annually and show no decline in yield as a result of bearing a full crop in the third season after planting. In fact, in the last three seasons the yields are considerably higher than in the first three years. Vines under method IIb which were pruned to only 2 fruiting canes in the third season, and consequently bore much less than a full crop in the third season, have not shown any greater yields in later seasons than occurred on the vines which bore a full crop in the third season. It was stated in Maryland Bulletin 286 that the very vegetative vines of method Ia apparently were "overbearing" with a full crop in the third season and as a consequence a decrease in yield occurred in the following two seasons. The average annual yield per vine for this method for the years after the third season is 293.9 ounces which is lower than the average annual yield from the vines of any of the other methods for the same years but the differences are not significant except in one case. The vines of method IIa which had a cane brought to the top wire at the end of the first season had an average annual yield of

TABLE I—RESULTS OF PRUNING CONCORD GRAPE VINES FOR EARLY BEARING, SHOWING AVERAGE YIELDS PER VINE IN OUNCES DURING SUBSEQUENT YEARS
(Vines planted in Spring of 1921)

Method		Pruning 1922	Pruning 1923	1923	1924	1925	1926	1927	1928	Total Yield per Vine in Ounces	Average Annual Yield per Vine in Ounces	After Third Season: Average Annual Yield per Vine Ounces	After Third Season: Average Annual Yield per Vine Pounds	After Third Season: Calculated Annual Yield per Acre in Pounds
I	(a)	2 buds (21)	4 canes laterals	296.8 ±6.10	201.2 ±8.12	203.5 ±14.0	442.0 ±19.2	315.6 ±18.8	307.5 ±10.5	1766.6	294.4 ±5.45	293.9	18.31	9,962
	(b)	2 buds (13)	3 canes laterals	270.1 ±4.73	235.1 ±9.03	217.5 ±17.9	460.2 ±25.2	342.7 ±19.8	299.8 ±14.8	1825.4	304.2 ±8.43	311.1 ±9.05	19.39	10,576
II	(a)	1 cane to top wire (10)	4 canes	274.2 ±20.7	241.0 ±9.70	224.3 ±7.22	573.8 ±25.8	280.6 ±19.4	356.7 ±31.2	1950.6	325.1 ±9.67	335.3 ±11.2	20.96	11,400
	(b)	1 cane to top wire (11)	2 canes on lower wire	192.0 ±9.98	254.9 ±14.4	224.5 ±15.9	425.2 ±23.1	296.6 ±10.2	326.3 ±17.3	1719.5	286.6 ±6.77	305.5 ±8.97	19.09	10,387
III		1 cane to lower wire (14)	2 canes plus upr'ght cane	249.7 ±5.44	227.1 ±12.0	219.2 ±12.8	437.9 ±20.4	307.6 ±16.0	329.2 ±19.2	1770.7	295.1 ±5.65	304.2	19.01 ±7.22	10,343

Note:—Numbers in parentheses in second column refer to number of vines.

335.3 ounces, which is a significant difference of 41.4 ± 12.8 ounces over the yield of the vines of method Ia. However, the yields of vines of method Ia in the last three years have shown that these vines have recovered from the effects of so-called "overbearing" in 1923.

In Table II are presented the average weights of new wood removed by pruning in the years 1926, 1927, and 1928 for the different methods. The vines were pruned according to the four-cane Kniffin system with 12 buds per fruiting cane. The number of canes was increased or decreased as the vegetative vigor of the vine warranted, using the weight of new wood removed as an indicator of vigor.

TABLE II—Showing the Average Weight of New Wood Removed by Pruning from Concord Vines Planted in 1921 and Bearing the First Crop in 1923.

(Weights in pounds).

Method		Pruning 1922	Pruning 1923	New Wood Removed 1926	New Wood Removed 1927	New Wood Removed 1928	Average New Wood Removed per Vine
I	(a)	2 buds	4 canes laterals	2.96	4.15	3.31	3.47
	(b)	2 buds	3 canes laterals	2.32	3.74	2.72	2.93
II	(a)	1 cane to top wire	4 canes	3.18	4.30	3.63	3.70
	(b)	1 cane to top wire	2 canes on lower wire	2.80	3.95	3.10	3.28
III		1 cane to lower wire	2 canes + upr't cane	3.03	4.37	3.54	3.65

The amount of new wood removed in pruning as shown in Table II also shows that the vines are not declining in vegetative vigor following the heavy cropping in early years. The vines of method IIb show the lowest weight of prunings but have been yielding large crops in these years.

In summarizing the data, it is apparent that bearing of a full crop by Concord vines in the third season did not reduce the bearing capacity or vegetative vigor of the vines in later years.

Literature Cited

1. Schrader, A. L. Growth studies of the Concord grape. Proc. Amer. Soc. Hort. Sci., 20:116–122. 1923.
2. Schrader, A. L. The Concord grape. Pruning and chemical studies in relation to the fruiting habits of the vine. Md. Agr. Exp. Sta. Bul. 286. 1926.

Berry Thinning of Grapes

By A. J. Winkler, *University of California, Davis, California.*

WITH the great expansion in the production of table grapes in California, there is a growing demand for methods of improving one or more of the factors, such as size of berry, color, and sugar content, which constitute quality. During the past season, the influence of berry thinning on weight of berry, coloring of the fruit, and compactness of the clusters of several varieties of *vinifera* grapes was studied. The results obtained with Tokay and Malaga are presented in this paper.

The berry thinning was done in two ways: (1) by removing enough of the rachis (main stem of the cluster) to leave about seventy berries, and (2) by cutting off all the branches on one side of the rachis and then cutting off the end of the cluster so as to leave about seventy berries. The first method requires the making of only one cut and is therefore very simple and rapid. The clusters when thinned by this method are short—being made up of the three to five or six primary branches at the base of the original cluster. The second method is most rapidly executed with a knife, but at best it requires twice as much time as the former. The clusters thinned by the second method are more nearly normal in shape since the branches left along the rachis tend to fill in the thinned side of the cluster by the end of the season.

There was no measurable difference in the improvement resulting from the two methods of thinning. In the tables and discussions that follow, the data will be presented without reference to methods of thinning, except in the matter of cost.

At the time the fruit was harvested, the weight of berry was determined for 40 to 50 representative clusters. The influence of thinning as well as time of thinning on berry weight is shown in Table I.

TABLE I—The Influence of Berry Thinning and Time of Thinning on Weight of Berry in Grams

Location of Plots	Check Plot	First Thinning 6-2-28	Second Thinning 6-11-28	Third Thinning 6-19-28
Tokay				
Van Buskirk—old vines Southwest of Lodi	5.3±.32	6.75±.12	5.7±.09	5.6±.05
Van Buskirk—young vines North of Lodi	4.4±.13	6.3 ±.09	5.3±.09	5.1±.05
Hoffman vineyard—East of Lodi	4.1±.09	5.1 ±.06	4.8±.08	4.4±.06
University Farm vineyard at Davis	4.0±.09	5.0 ±.06	4.9±.07	4.4±.07
Malaga				
University Farm vineyard	3.0±.05	4.0 ±.07	3.3±.07	3.2±.06

The figures of Table I indicate that the mean weight of berry of Tokay on the three plots at Lodi and one at Davis was increased from 4.4 grams to 5.3 grams or 24 per cent. The greatest increase

32 per cent, was obtained by the June 2nd thinning, which was as early as the thinning could be done after the berries had set. The second thinning gave the next largest increase, 18 per cent, while the last thinning on June 19th resulted in the smallest increase. The response to berry thinning by the Malaga was very similar to that of the Tokay, but the increases were smaller except for the earliest thinning.

In the Tokay where the color of the fruit is the main indication of suitability for picking, the amount of fruit harvested at each picking offers a basis for comparing the development of color of the fruit in the thinned and check plots. The fruit of the several plots was picked for color as is the commercial practice by commercial pickers. The amount of fruit harvested from the thinned and the checked plots at the first and second pickings is shown in Table II.

TABLE II—The Influence of Berry Thinning on Coloring as Indicated by the Amount of Fruit Harvested at Each Picking

Location	Date of Harvest	Picking	Pounds of Fruit Harvested			
			Check	First Thinning 6–2–28	Second Thinning 6–11–28	Third Thinning 6–19–28
Van Buskirk vineyard (old vines)	Sept. 12	1st.	46	203	223	312
	Sept. 22	2nd.	372	402	301	199
Van Buskirk vineyard (young vines)	Sept. 18	1st.	7	226	245	159
	Sept. 29	2nd.	14	221	124	219
Hoffman vineyard	Sept. 14	1st.	98	146	168	149
University Farm vineyard	Sept. 16	1st.	6	136	184	137

The figures of Table II show that five times as much fruit was harvested from the thinned plots of the Van Buskirk vineyards as from the check plots at the first picking. The first and second pickings, yielded more than twice as much fruit from the berry thinned as from the check plots. The difference in coloring in favor of the thinned plots for the other vineyards was about the same. In addition to developing earlier, the color of the thinned fruit was more uniform; that is, there was less difference in the shade or brilliancy of color on the exposed side and shaded (protected) side of the clusters. The time of thinning had little or no influence on the coloring of the fruit.

The importance of the earlier coloring is shown by the prices obtained. The grapes picked from the Van Buskirk vineyard, west of Lodi, on September 12th, brought 15 cents a package more than those picked from this vineyard on Sept. 22nd although there was no difference in quality.

A large number of clusters from each of the plots in the several vineyards were weighed and the berries counted. These weights and counts for the three vineyards of Tokay at Lodi are given in Table III.

Although 50 to 65 per cent of the berries were removed at the time of thinning, the figures of Table III show that the decrease in the number as a result of thinning ranged from 40 to 45 per cent. This apparent discrepancy in the number of berries removed seems to

indicate that many of the berries on the unthinned clusters dropped after the time of thinning, while most, if not all, of the berries retained on the thinned clusters, as a result of better nutrition following the reduction in number, developed to maturity.

TABLE III—THE INFLUENCE OF BERRY THINNING ON THE WEIGHT OF CLUSTER AND NUMBER OF BERRIES PER CLUSTER

Location of Vineyards	Check	First Thinning	Second Thinning	Third Thinning
Weight of Cluster in Grams				
Average for 3 vineyards at Lodi.....	459±28	334±13	338±10	306±7
Percent decrease as a result of thinning		27.2	26.2	33.4
Number of Berries				
Average for 3 vineyards at Lodi.....	109±4.8	61±2.1	65±1.8	62±1.3
Percent decrease..................		44.3	40.7	43.4

The beneficial influence of berry thinning on the subsequent development of the retained berries is further illustrated by the results of some thinning done at Davis after full bloom, but before all of the berries had set. Although 50 per cent or more of the berry forms were removed, the thinned clusters had only 4 per cent less berries at harvest than the non-thinned clusters. These results further indicate that berry thinning should not be done before the berries have set. Owing to the great increase in the number of berries that set in this test, together with the reduction in size as a result of thinning, these clusters were so compact that they were worthless.

As shown by Table III, the percentage decrease in weight of cluster was not so large as the decrease in the number of berries to a cluster. This follows as a result of the increase in size of berry.

The clusters of the berry thinned fruit were less compact than those of the check plots despite the fact that the berries were larger. As shown by the figures of Table IV, there was no increase in the length of cluster after blooming. There is also no difference in the increase of length of the first branch of the rachis of the clusters of the thinned and check plots. The increase in length of pedicle is directly proportionally to increase in berry diameter, therefore it has little or no influence on compactness of clusters since the diameter of the berries of the thinned plots was only slightly greater than that of the check plots.

The improvement in the compactness of the clusters must, therefore, result primarily from the removal of a part of the middle and apical end of the cluster which, in these varieties, are usually most compact. In the first method of thinning, a very considerable part of the cluster, usually from beyond the middle of the cluster, is entirely removed; while in the second method sufficient branches are removed in the middle and the end lopped off which prevent the cluster from becoming too compact as the berries increase in size.

Berry thinning will cost from five to twenty dollars per acre according to the age of the vines, the number of clusters, the method of thinning employed, etc. However, in vineyards where good fruit can

TABLE IV—THE ELONGATION OF TOKAY AND MALAGA CLUSTER PARTS AFTER THE BLOOMING SEASON

Measurements	Length of Parts—in Centimeters			
	Just After Full Bloom	All Berries Set	Berries 1/3 Grown	At Harvesting
Length of Rachis (Main stem of cluster)	19.8±.3	20.6±.3	20.4±.4	20.6±.3
Length of first branch of the rachis	5.4±.24*	5.3±.40*	5.8±.14*	6.1±.28*
	5.2±.17	5.1±.16	5.7±.28	5.8±.20
Length of pedicle (cap stem)	.77*	.91*	.98*	.99*
	.75	.89	.99	.98

*Berry thinned. All other measurements of clusters not thinned.

be produced, but where the size of the berries is small or where the coloring of the fruit is poor or slow in developing, it would seem that berry thinning offers the grower a chance to improve the quality of the fruit greatly. On the contrary, in vineyards where the berries attain good size, color well, and the clusters are not too compact, little or nothing can be expected of berry thinning.

Some Responses of the Seedless Varieties of *Vitis Vinifera* to Girdling

By H. E. JACOB, *University of California, Davis, California.*

GIRDLING of Black Corinth vines for the production of the Greek currant raisins of commerce, is an old practice and is in use wherever these raisins are produced. In recent years, attempts have been made in California and elsewhere to apply this method to table grapes in efforts to produce table fruit of finer appearance and better quality. Some of these attempts have met with more or less success, especially with certain of the seedless varieties. In response to demands in California for reliable information concerning what results might reasonably be expected and how and when the girdling operation should be done, an investigation was started which has now been under way for two years. Some interesting results have been obtained.

The experiments have been limited to three varieties, namely, Black Corinth, Sultanina (Thompson), and Monukka. The Black Corinth is used only for raisins but the Sultanina and Monukka, while usually considered primarily as raisin varieties, are used to a considerable extent as table grapes. Limitations of time have prevented much work with other varieties.

The method used in these experiments is similar to that commonly used in commercial vineyards. A ring of bark 3/32 to 1/8 of an inch wide is removed entirely around the member girdled. In the initial tests, three positions for girdling were used, viz., trunk, arms, and fruit canes. Girdling of the arms was discontinued after the first series of tests for the work was slow and difficult owing to the knotty, gnarled nature of the arms, and the slow healing of the wounds.

The trunks to be girdled were previously cleaned, the rough outer bark being removed by using a steel mitten. This is an essential operation and requires more time than the girdling itself. It can, however, be done by less experienced workmen. The ring of bark was then removed by means of a special double-bladed knife. The wounds of all except certain check vines were then covered either with mounds of earth or cheese-cloth bandages. After the first series of tests, all of the girdling wounds on the trunks were covered with bandages. This permits the selection of the smoothest and most accessible place on the trunk for girdling, whereas covering with soil necessitates doing the girdling near the ground where the trunks are seldom straight and smooth. The bandages used were strips of cheese-cloth about 1½ inches wide and long enough to go twice around the trunk and allow the ends to be tied together. They were removed after the wounds had callused over.

The canes were girdled without previous preparation and the wounds were not covered. A ring of bark was removed from each fruit cane of a vine, immediately below the lowest fruit-bearing shoot. Usually sterile shoots grow near the base of the cane and it is desirable to have the wound beyond these shoots so that they can be used, if necessary, for fruit canes the following season.

The length of time required for the girdling wounds to heal is indicated by the figures given in Table I. The trunk wounds which were covered required about 3 to 4 weeks. Those not covered required about one week longer. No difference was noticed between wounds covered with earth and those covered with cheese-cloth The wounds on the canes healed more slowly and less perfectly than those on the trunk.

TABLE I—TIME REQUIRED FOR GIRDLING WOUNDS TO HEAL

Place of Girdling	No. of Wounds Examined	Covering	Number of Wounds 75 Per cent or More Healed Over					
			After 3 wks.	After 4 wks.	After 5 wks.	After 6 wks.	After 7 wks.	After 8 wks.
Trunk	287	Cloth bandages	280	287				
Trunk	6	Earth	5	6				
Trunk	23	Not covered	9	21	23			
Canes	117	Not covered	16	89	111	113	113	113

In 1927, lots of vines of all three varieties were girdled at six stages of development: Beginning of bloom, full bloom, end of bloom, berries well set, berries approximately one-fourth grown, and berries one-third to one-half grown. The number of vines available for this work is limited, and in 1928 the number of lots was reduced so as to increase the number of vines in each lot. Three stages of development were selected for girdling all three varieties, namely beginning of bloom, end of bloom, and berries approximately one-fourth grown. In addition, a lot of Monukka vines was girdled when the fruit gave a maturity test of 13° Balling (Hydrometer). Discussion in this paper relating to time of girdling will be limited to the stages used in 1928.

From four to thirty vines were used in each experiment. Except for the purpose of comparing trunk and cane girdling, however, no data are included in the following tables that were obtained from lots of less than 9 vines, and most lots included 15 or more vines.

Effects of Girdling

Observations were made which were intended to show: The effect of girdling and the time of girdling on the quantity of crop, the set of berries, the size of the berries, the size of the clusters, the compactness of the clusters, and the earliness of ripening; and a comparison of trunk and cane girdling.

Girdling between the time of beginning of bloom and the time that the berries are one-fourth grown, apparently causes a considerable increase in crop when the vines are not thinned or are thinned so as to leave about the same number of clusters on the girdled and ungirdled vines. In these experiments, the Black Corinth were not thinned. The Sultanina and Monukka were blossom thinned, and about the same number of clusters were left on the girdled and ungirdled lots.

The increase appears to be greatest in the Black Corinth, on the vines girdled between the beginning and the end of the blooming period. Since the increase in crop is the effect most desired in this variety, it appears that commercial girdling should be done at this time. The figures for Sultanina and Monukka given in Table II show little if any difference in the crop of vines girdled between beginning of bloom and when the berries were one-fourth grown. In these varieties, increase in quantity of crop is not the response particularly desired and all of the vines of these varieties girdled in 1928 were heavily thinned in an attempt to reduce the crop on the girdled vines to proportions similar to the ungirdled vines.

TABLE II—The Effect of Girdling and the Time of Girdling on Quantity of Crop

Variety	Year	Time of Girdling and Weight of Crop in Kilos			
		Beginning of Bloom	End of Bloom	Berries Approx. ¼ Grown	Check Not Girdled
Black Corinth .	1927	7.3±0.86*	4.9±0.66	2.8±0.39	1.9±0.18
Black Corinth .	1928	10.8±0.46	11.6±0.35	6.2±0.32	3.2±0.19
Sultanina......	1927	15.6±0.78	14.7±0.96	12.7±0.83	9.8±0.89
Monukka......	1927	20.4±0.88	18.1±0.28	21.7±0.95	10.1±0.88

*Probable errors calculated by Bessel's formula.

Calculation made by dividing the average weight of the clusters by the weight of berry, indicate that an increase in the set of berries resulted from the earlier girdlings. This increase is greatest on vines girdled during the blooming period. Girdling after the berries are one-fourth grown apparently produces little increase in the number of berries that mature. The figures in Table III, illustrate these points.

TABLE III—THE EFFECT OF GIRDLING AND THE TIME OF GIRDLING ON THE NUMBER OF BERRIES PER CLUSTER

Variety	Year	Time of Girdling and the Number of Berries per Cluster*			
		Beginning of Bloom	End of Bloom	Berries Approx. ¼ Grown	Check not Girdled
Black Corinth .	1927	276	186	173	117
	1928	361	412	268	305†
Sultanina......	1927	584	486	445	400
	1928	586	649	369	327
Monukka......	1927	495	380	385	277
	1928	411	350	255	249

*The number of berries per cluster is calculated by dividing the average weight of cluster by the weight of berry.
†This lot of vines had been girled in 1927 and it is possible that the girdling of the previous year has affected the set of berries for this season.

With Black Corinth, all girdling from the beginning of bloom until the berries were approximately one-fourth grown resulted in a large increase in size of berry. The behavior of Monukka and Sultanina was somewhat different. Girdling at the beginning of bloom produced little or no increase in the size of the berry. From the end of the blooming period until the berries were one-fourth grown, girdling produced great increases. The increase appears to be greatest on vines girdled when the berries are about one-fourth grown, and in the 1928 experiments, was of a magnitude of about 40 per cent of the check. The figures of Table IV show the results obtained in 1928.

This increase in size of berry is the main object for which varieties of table grapes are girdled. Since girdling when the berries are one-fourth grown produced little or no difference in the set of berries but gave the greatest increase in size of berry in Sultanina and Monukka, it appears that this is the best time to girdle these varieties.

TABLE IV—THE EFFECT OF GIRDLING AND THE TIME OF GIRDLING ON THE SIZE OF BERRY

Variety	Time of Girdling and Weight of 100 Berries in Grams			
	Beginning of Bloom	End of Bloom	Berries Approx. ¼ Grown	Check Not Girdled
Black Corinth..........	31± 0.34	31±0.52	33±0.83	19±0.24
Sultanina..............	153± 2.32	191±6.07	230±2.25	155±3.41
Monukka..............	247±10.17	307±5.80	356±6.33	252±6.33

Increase in the weight of clusters results from both increased set of berries and increased size of berries. The combined effect of these increases on the weight of cluster is shown in Table V. It is peculiar that in 1927, the earliest girdlings resulted in the heaviest clusters, while in 1928 all three varieties produced the heaviest clusters on vines girdled at the end of the blooming period. No explanation of this difference in behavior between the two seasons is available.

TABLE V—THE EFFECT OF GIRDLING AND THE TIME OF GIRDLING ON WEIGHT OF CLUSTER

Variety	Year	Time of Girdling and Average Weight of Cluster in Grams*			
		Beginning of Bloom	End of Bloom	Berries Approx. ¼ Grown	Check Not Girdled
Black Corinth	1927	102	68	43	29
	1928	112	129	87	58
Sultanina	1927	772	739	722	533
	1928	902	1240	849	506
Monukka	1927	1015	989	952	481
	1928	1015	1075	907	628

*The average weight of cluster is calculated by dividing the weight of crop by the number of clusters per vine.

The increased weight of cluster is not accompanied by an enlargement of the framework of the cluster. The data obtained, indicate that none of the girdling caused an important enlargement of the framework. The figures presented in Table VI illustrate this point. In no case is the difference between the mean length of clusters from the girdled and check lots significant.

TABLE VI—THE WEIGHT AND LENGTH OF THE CLUSTERS FROM GIRDLED AND UNGIRDLED VINES—MONUKKA

Time of Girdling	Beginning of Bloom	End of Bloom	Berries Approx. ¼ Grown	Not Girdled
Ave. wt. of clusters in grams*	1015	1075	907	628
Mean length of clusters in cm	28.6±0.36	29.2±0.29	27.2±0.31	28.2±0.24

*The average weight of cluster was calculated by dividing the weight of crop by the number of clusters per vine.

An increase in the number of berries or in the size of the berries, or both, without a corresponding increase in the framework of the clusters, naturally results in greater compactness. The only remedy for an undesirable excessive compactness, appears to be hand thinning of the berries as discussed by Winkler in his paper "Berry Thinning of Grapes" appearing elsewhere in these Proceedings.

The influence of girdling upon maturity or the rate of ripening of grapes is a subject upon which all growers do not agree. It appears likely that at least a part of the disagreement can be attributed to the difference in methods or standards by which maturity is measured. The commonly accepted method in California at the present time is by means of the Balling or Brix scale hydrometer. The figures of Table VII show that when this criterion is used, no advance in maturity attributable to girdling up to and including the time that the berries are approximately one-fourth grown, can be measured. There does appear to be a slight advance caused by girdling at the beginning of the ripening period as is shown by the Monukka girdled when the fruit tested 13° Balling (Table VII). The difference between this lot and the corresponding check is small but significant.

The quantity of crop on the vines and hence the practice of thinning the fruit appear to affect the rate of ripening more than does the girdling. In Table VII, therefore, the type of thinning and the quantity of crop are given in order to show the effect of girdling on maturity. With Sultanina and Monukka, both blossom and berry thinning of the clusters have resulted in slightly earlier maturity.

If palatability and appearance are used as criteria of maturity, as was the case with many growers until recently, results somewhat contrary to those shown in Table VII may be obtained. It has been the observation of many growers that the fruit from girdled vines has been edible somewhat in advance of the fruit from ungirdled vines. Since the advent of the use of the hydrometer, however, the general consensus of opinion among commercial growers is that girdling does not hasten maturity when sugar content alone is used as a measure of maturity.

TABLE VII—THE INFLUENCE OF GIRDLING, THINNING AND QUANTITY OF CROP ON MATURITY

Time of Girdling	Type of Thinning	Crop per Vine (Kilos)	Maturity (Degrees Balling)
	Black Corinth		
Beginning of bloom	None	10.8±0.46	27.1±0.26
End of bloom	None	11.6±0.35	26.1±0.41
Berries ¼ grown	None	6.2±0.32	27.5±0.24
Not girdled	None	3.2±0.19	27.7±0.26
	Sultanina		
Beginning of bloom	Clusters	12.9±0.92	22.3±0.25
End of bloom	Clusters	18.1±1.10	20.2±0.34
Berries ¼ grown	Clusters	14.6±0.93	21.7±0.28
Not girdled	Clusters	11.8±0.61	22.5±0.71
Not girdled	None	17.7±1.22	22.4±0.48
Berries ¼ grown	Clusters and berries	7.2±0.47	23.2±0.31
Not girdled	Clusters and berries	7.2±0.23	24.0±0.26
	Monukka		
Beginning of bloom	Clusters	19.7±0.72	18.4±0.30
End of Bloom	Clusters	22.8±0.61	17.7±0.23
Berries ¼ grown	Clusters	17.5±0.40	19.0±0.13
Not girdled	Clusters	14.5±0.41	20.6±0.20
Not girdled	None	20.4±0.60	20.6±0.21
Fruit 13° Balling	None	21.2±0.67	21.8±0.27
Beginning of bloom	Clusters and berries	12.5±1.92	21.1±0.11
End of bloom	Clusters and berries	12.4±0.54	21.4±0.22
Berries ¼ grown	Clusters and berries	9.2±0.44	22.0±0.16

COMPARISON OF TRUNK AND CANE GIRDLING

In the 1927 work, equivalent series of Black Corinth and Sultanina vines were girdled on the trunks and on canes. These trials indicated that girdling the trunks of the vines, in general, gave better results than girdling the fruit canes. The difference, however, was not great. The number of vines available for these experiments is limited and in view of the 1927 results, only one series of 4 vines of Sultanina in each lot was used in 1928 for tests of the relative merits of trunk and cane girdling. This series, in which the fruit was carefully

thinned, fails to show that one system produces any better fruit than the other. A summary of the 1928 results is given in Table VIII.

TABLE VIII—COMPARISON OF GIRDLING THE TRUNK AND FRUIT CANES OF SULTANINA

Time of Girdling	Position of Girdle	No. of Vines	Crop per Vine (Kilos)	Wt. of 100 Berries (Grams)	Maturity (Degrees Balling)
Beginning of bloom........	Trunk	4	18.4*	144.1	19.0
Beginning of bloom........	Canes	4	16.4	154.0	20.4
End of bloom.............	Trunk	4	15.5	165.5	18.0
End of bloom.............	Canes	4	17.2	164.6	17.2
Berries approx. ¼ grown...	Trunk	4	21.2	235.6	17.8
Berries approx. ¼ grown...	Canes	4	18.1	216.7	18.1

*Probable errors have not been calculated for these averages since the number of vines used in each lot is so small that probable errors would be of little or no value.

The Management of Filler Apple Trees by Ringing and Severe Heading Back*

By F. N. FAGAN, *Pennsylvania State College, State College, Pennsylvania.*

AT the twenty-second annual meeting of our Society held in Kansas City in December 1925, the Pennsylvania State College Agricultural Experiment Station presented a paper on "The Effect of Ringing Filler Trees in an Apple Orchard and Its Commercial Possibilities." At that time we stated that the results of this work, which was begun in 1922, indicated commercial possibilities, and that we would ring all the fillers in a fifteen acre orchard of Stayman, McIntosh and Baldwin. The ringing of all fillers in this orchard was done in early June 1926, (between June 1 and 10). At that time 1125 fillers had nine seasons' growth, thus the ringing was made in the early growing period of their tenth season in 1926.

The trees had bloomed heavily in the spring of 1926 and by June 1st, indications were that all the trees would set a heavy crop for the fall of 1926. This led us to believe that the 1927 crop in the orchard would be rather light. With the heavy set of fruit in 1926 we were doubtful whether ringing should be given the fillers, but knowing the orchard was becoming very crowded, it was decided to ring and get as large a crop as possible in 1927 from the fillers.

The ringing of the fillers by removing ¼ to ½ an inch ring of bark to cambium did not cut the crop already set for 1926. This crop was so heavy and shaped the tree by spreading the branches to such an extent that we knew we could not let the fillers remain over the 1927 growing season unless they were severely headed in. Figure 1 shows the size of the trees in the fall and winter of 1926, and Figure 2 shows the fillers after they were headed back that winter. We estimate that at least one-half of the bearing surface was removed

*Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 470.

in this severe pruning. All fillers were again ringed June 1 to 10, 1927. Scoring seems to be as effective as removing the ring of bark. This consists of merely making two or three heavy knife cuts through the bark as shown in Figure 3, without removing the bark. We have practiced this since 1926. The knife is forced into the bark to the sap wood. In 1927 we made two cuts on the smaller trees and three cuts on the larger ones.

In 1927 the 375 filler trees of McIntosh (severely headed) averaged 1.77 bushels per tree, while 131 permanent trees (not headed) averaged 1.92 bushels per tree. During the winter 1927–1928 the fillers were again "headed-in" severely to prevent crowding of the permanent trees. The 1928 crop averaged 2.68 bushels on the filler trees, and 7.56 bushels on the permanent trees.

Since the 1926 Baldwin crop was very heavy, the markedly biennial bearing tendency of this variety would be expected to make a light crop in the following year. In 1927 the 313 filler trees (ringed in 1926 and 1927 and headed-in during the winter of 1926–1927) averaged 0.96 bushel per tree, while 121 permanent trees (not ringed or headed-in) averaged 0.80 bushel per tree. The 1928 crop suffered from spring frost. However, on 145 filler trees where the damage seemed least, the yield averaged 1.43 bushels, and on 67 of the permanent trees the average was 1.56. For all trees in the experiment the respective averages were 0.66 and 0.86.

The 1928 Stayman crop averaged per tree: on 375 filler trees 1.88 bushels, on 146 permanent trees, 3.90 bushels.

The 1927 harvest notes are interesting, (trees at the end of eleventh growing season): In the McIntosh block, 375 filler trees severely headed produced 667.25 bushels, averaging 1.77 bushels per filler tree; and 131 permanent trees not headed produced 225.50 bushels, an average per permanent tree of 1.92 bushels.

In the dormant season of 1927–28 the fillers in the fifteen-acre orchard were again severely "headed-in" to prevent the permanent trees being crowded. The 1928 harvest of McIntosh is also interesting.

Three hundred seventy-five filler McIntosh harvested 1007.35 bushels, an average per tree of 2.68 bushels; and 131 permanent trees harvested 991.65 bushels, an average per tree of 7.56 bushels.

In the Baldwin block the records are even more interesting in that the 1926 crop was very heavy and with the alternate bearing condition common with this variety we should expect a light crop in 1927. Three hundred thirteen filler Baldwin trees, ringed in 1926 and 1927 and "headed-in" in the winter of 1926–27, harvested 302 bushels, an average of .96 bushels; and 121 permanent trees (not ringed or headed), harvested 97 bushels, an average of .80 bushels.

In 1928 this block of trees set only a small crop due to frost injury to all our Baldwin trees. However, the records are interesting. One hundred forty-five filler Baldwin trees harvested 207.75 bushels, an average of 1.43 bushels for 145 trees, and an average of .66 bushels

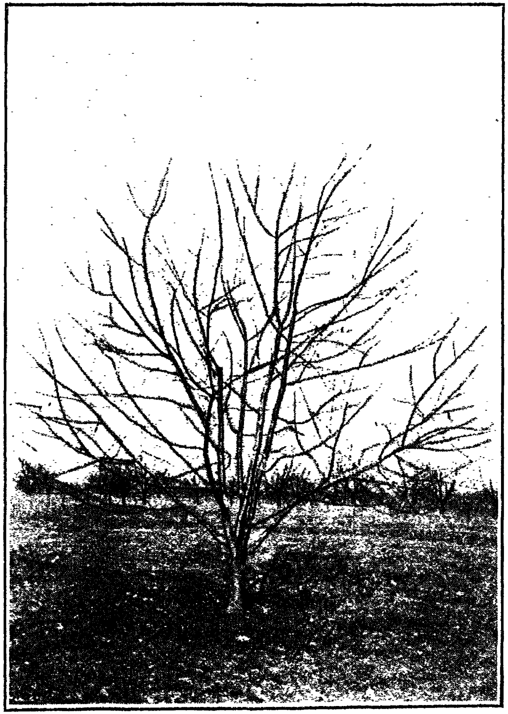


Fig. 1. A Stayman filler before being headed.

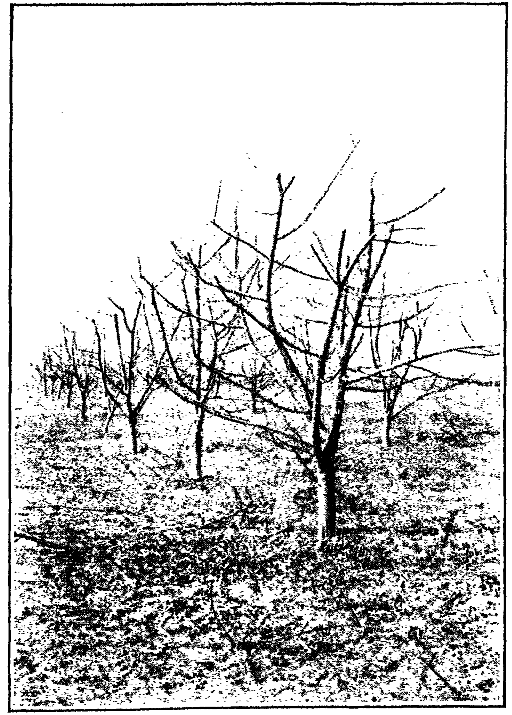


Fig. 2. Stayman fillers severely headed in winter of 1926 and again in winter of 1927.

FIG. 3. McIntosh tree trunk. Bark ring removed in 1925 and again in 1926; scored with 2 knife cuts in 1927 and with 3 knife cuts in 1928, bark not removed in scoring.

FIG. 4. Stayman 8 years old. Trees on right ringed preceding year—yield 4 bus. per tree. Trees on left not ringed—yield 1 bu. per tree.

for 313 fillers. The permanent trees set fruit on only 67 trees and harvested 104.75 bushels, an average of 156 bushels for 67 trees, and an average of .86 for 121 permanent trees.

In the Stayman block of trees another experiment was being conducted which interfered with the taking of the ringing records in 1927. However, the fillers had been ringed in June 1926, 1927, and 1928, and severely headed each year. The 1928 harvest indicates about the same results as the other two varieties, namely, 375 filler trees harvested 707 bushels, an average of 1.88 bushels, and 146 permanent trees harvested 579 bushels, an average of 3.90 bushels.

At the close of the 1928 harvest, one-half of the fillers were removed from the orchard, leaving the fillers in the center of the square for future ringing and "heading-in" work, which will be continued. This will permit of five more years of study of continuous ringing with 405 trees, in comparison with 405 permanent trees not ringed. Referring to Figure 4 and to our report in the 1925 Society Proceedings when the trees were nine years old, (ringed in the eighth year), when an increase of three bushels per tree was obtained on Stayman and McIntosh and an increase of one bushel per tree on Rome, with an increare of over one bushel in the case of Baldwin, we offer the following conclusions and are recommending to orchardists in Pennsylvania:

1. When filler apple trees reach a size that will indicate their ability to produce three bushels of apples, and have not yet borne fruit, ringing is a desirable commercial practice.

2. Ringing has caused a desirable set of fruit even when fillers have been severely headed back, when ringing is practiced year after year with the same tree.

3. Yearly ringing will not kill but does retard growth to some extent.

4. In our experience, ringing should be practiced only on trees making a satisfactory terminal growth of at least twelve inches.

5. Trees standing on ledge rock or in thin soil are more liable to be injured by ringing.

6. When ringing is once started with fillers it should be continued annually or alternate bearing habits will be intensified.

7. In our experience ringing should be practiced about the time length growth of terminals ceases to be of a rapid nature. This, in Central Pennsylvania, generally comes between May 25 and June 15.

8. If rings of bark are removed to cambium layer, a strip of grafting tape should be placed over the ring removed.

9. Scoring seems to be as effective as removing the ring of bark.

Further Studies on the Effect of Commercial Forms of Nitrogenous Fertilizers as Applied to Winesap Apple Trees

By R. S. Marsh, *University of Illinois, Urbana, Illinois.*

THIS paper reports additional data on the investigation begun in 1926 on Winesap apple trees twenty-five years old, located near Hamburg, Illinois. A preliminary report was published at the completion of the first year's work (1).

In 1927 the following rates of application per tree were discontinued, 3 pounds of nitrate of soda, 2½ pounds of ammonium sulfate, and 2½ pounds of calcium cyanamide. This was done because these amounts did not seem large enough to produce significant differences in tree response. Also, a change was made in 1927 with one of the calcium cyanamide blocks. Five trees which received 4½ pounds of calcium cyanamide in 1926 were dropped from the experiment, and another block of six trees which received 4½ pounds of ammonium sulfate in 1926 was fertilized with 4½ pounds of calcium cyanamide in 1927 and 1928. In each year the fertilizers were applied two weeks before full bloom. Other than these two modifications, the investigation was continued as reported in 1926.

As in 1926 two lots of spur samples were taken this season, one when the trees were in full bloom (May 2) and one on June 14. On the former date, only flowering spurs were taken; and on the latter date, spurs that had set fruit were collected. One-year-old wood, present season's growth, leaves and flower parts, were included in the first sampling. The second sampling included the same parts except the immature fruits were discarded. Spurs of apparently the same age were selected and each sample included spurs from all parts of the tree. The samples were oven-dried to constant weight and finely ground for analysis. Total nitrogens were run by the Kjeldahl method with salicylic acid added so as to include nitrate nitrogen. Results of the analysis for total nitrogen in bearing spurs for 1926 and 1928 are given in Table I.

Spur samples collected May 2, 1928, show by analysis that the treated blocks gave in general slightly increased total nitrogen percentages over the untreated trees. The differences in total nitrogen percentages among the untreated and treated blocks were much larger in 1926 than were found this past season. Moreover, nitrate of soda gave the greatest increase in 1926 and ammonium sulfate gave the greatest increase in 1928 according to the analysis of spurs collected on May 2. Total nitrogen content in spurs collected June 14, fail to show any significant differences between nitrate of soda or ammonium sulfate treatments. Again these figures are in agreement with the data of Schrader and Auchter (2) which prompts this statement: The differences in tree response between the two nitrogen carriers (ammonium sulfate and nitrate of soda) appear smaller each year, especially where large amounts of these materials are used, and when the lack of quickly available nitrogen is not such a limiting factor.

TABLE I—PERCENTAGES OF TOTAL NITROGEN ON DRY WEIGHT BASIS OF SPURS FROM 28-YEAR-OLD WINESAP APPLE TREES

Date of Treatments	Fertilizer Treatments Pounds per Tree April 15, 1926–April 19, 1928						Percentages of Nitrogen at Different Sampling Dates May 19, 1926–May 16, 1928			
	Sodium Nitrate 9 Pounds $NaNO_3$	Sodium Nitrate 6 Pounsd $NaNO_3$	Ammonium Sulfate 6¾ Pounds $(NH_4)_2SO_4$	Ammonium Sulfate 4½ Pounds $(NH_4)_2SO_4$	Calcium Cyanamide 6¾ Pounds Ca $(CN)_2$	Calcium Cyanamide 4½ Pounds $Ca(CN)_2$	SodiumNitrate 6 pounds $NaNO_3$	Ammonium Sulfate ounds$(NH_4)_2SO_4$	Calcium Cyanamide 4½ Pounds $Ca(CN)_2$	Check
May 15, 1926....	2.90	2.98	2.86	2.61	2.80	2.77	—	—	—	2.48
June 29, 1926....	2.08	1.89	1.82	1.80	1.82	1.76	1.88	2.02	1.82	1.73
May 2, 1928....	2.68	2.64	2.73	2.87	2.64	2.81	2.67	2.59	2.59	2.58
June 14, 1928....	2.31	2.05	2.32	1.99	2.08	1.96	2.07	2.04	1.78	1.77

Note. The various blocks of trees were given the same fertilizer treatments in 1927 as in 1928. The dates of application in 1927 were April 6 and May 9.

Although there seems to be no significant differences between the nitrate of soda and ammonium sulfate treatments, the difference in total nitrogen percentages of spurs from trees treated with calcium cyanamide compared with the results obtained with the other two materials, according to the analysis of June 14, is sufficient to be significant. It is noted that where 4½ pounds of cyanamide is applied on May 16, there is no response in increased total nitrogen content over the check. Also, where the larger amounts were applied on April 19, the analysis of spurs collected June 14, show that the increase of total nitrogen over the check for 6¾ pounds of calcium cyanamide was only 55 per cent of the increase of 6¾ pounds of ammonium sulfate over the check. It would seem that calcium cyanamide is more slowly available than nitrate of soda or ammonium sulfate. Not only does the analysis of spurs for June 14, 1928, show this to be true, but also the analysis of spurs in 1926 indicates such to be the case.

Total nitrogen percentages are in agreement with data presented for spurs collected May 1 and June 15, and analysed by Murneek (3). Hence these results lend additional evidence to his statement that nitrogenous substances are moved into the bearing spur in abundance during fertilization and fruit setting.

The following conclusions can be drawn: Nitrate of soda and ammonium sulfate seem to be equally effective in increasing the total nitrogen content of spurs on trees that are annually fertilized. Calcium cyanamide is more slowly available than nitrate of soda and ammonium sulfate.

LITERATURE CITED

1. MARSH, R. S. Preliminary studies of commercial forms of nitrogen fertilizers applied to Winesap apples. Proc. Am. Soc. Hort. Sci., 23:218–221. 1926.
2. SCHRADER, H. LEE and AUCHTER, E. C. The comparative effects of different nitrogen fertilizers on bearing trees low in vigor. Proc. Am. Soc. Hort. Sci., 24:229–233. 1927.
3. MURNEEK, A. E. Nitrogen and carbohydrate distribution in organs of bearing apple spurs. Mo. Agr. Expt. Sta. Res. Bul. 119. 1928.

Seasonal Variation in the Nutrient Condition of Apple Trees as Indicated by Catalase Activity

By Arthur J. Heinicke, *Cornell University, Ithaca, N. Y.*

It is now generally conceded that it is desirable to know the internal conditions of fruit trees which ultimately bring about such manifestations as shoot growth, flower bud formation, and the like. The difficulty of making frequent chemical determinations of a large number of individuals presents a serious obstacle to the widespread adoption of this valuable means of diagnosis.

While we are still in the dark as to the metabolic function of catalase, the activity of this enzyme nevertheless affords a convenient and highly sensitive index to some changes in the internal condition of apple tree tissue. Variations in vigor are accompanied by marked changes in catalase activity. That there is a high correlation between nitrogen content of the tissue and its ability to destroy hydrogen peroxide has been indicated by Auchter and others and recently confirmed by MacDaniels and Curtis (unpublished). It has also been shown that the internal condition causing an accumulation of carbohydrates without further addition to the nitrogen content depresses catalase. The enzyme is also influenced by many other factors such as hydrogen ion, chlorophyll content, iron content, and the like. On the basis of the many relationships between the internal conditions of the tissue and its catalase activity, it seems worthwhile to secure more data along these lines in the hope that they may prove helpful with other measurements in studying the individual variations in response to cultural conditions or experimental treatments.

Material and Methods

McIntosh apple trees 14 to 17 years old growing in the Cornell orchard at Ithaca, N. Y., furnished the tissues for the tests described in this paper. At frequent intervals during the seasons of 1927–1928 separate samples were obtained for a number of trees from (a) the live bark of trunk about one foot above ground, (b) from the bark of each of 2 branches 10 cm. in circumference, and (c) from the bark of the main roots 6 inches below the ground and within a half foot of the trunk. The samples consisted of 3 disks of bark from the cambium region out, each 5 mm. in diameter, taken at different points on the circumference of the branch. Special emphasis is placed upon the determinations with these bark samples since they represent tissues present throughout the year and which persist for many years in succession.

At less frequent intervals, samples were also obtained from the same trees to represent the leaves, active growing points, buds, and "bud insides." The leaf samples consisted of 7 mm. disks, one from each of 20 terminal leaves on non-fruiting spurs which made about 2 cm. of growth and which arose from 1926 or 1927 shoots. There were 10 selected buds and 15 "bud insides," or 15 active growing points for the sample of these tissues. Samples were usually obtained in duplicate.

Too much emphasis cannot be placed upon the selection of samples for determinations which are to be compared in different individuals and at different seasons. In the case of buds, for example, the tissues vary with the size as well as the time in which the terminal bud has formed. This depends, among other things, upon the size of the crop and whether the tree is in its "on" or its "off" year. If we make our selection on a given date, we may be comparing buds in one case which are a week or ten days younger than those in another case. When we use buds from non-fruiting spurs on a heavy flowering tree, we are generally selecting the weakest buds, and these must be compared to the weakest buds on non-fruiting trees. The selection of comparable material is a distinct horticultural problem, and it requires only a very casual reading of the recent literature to discover that the analyst has not always fully appreciated the important differences that may exist in so-called similar tissues.

Methods of preparing the bark samples for catalase determinations have been previously described and reference is hereby made to the standard procedure. (1) Special attention should be called to the importance of proper neutralization. The use of prepared chalk seems to be far more effective than other forms of calcium carbonate for this purpose.

The procedure of determining the catalase activity rests upon the principles already described (1). A machine has been developed which gives automatic records of activity, and facilitates the mechanical operations of agitation. It is now possible to make 12 determinations in the time previously required for one test. This machine will be described in detail in another publication.

The standard for the comparison of catalase activity used in this paper is the number of seconds required to develop 2cc oxygen from 2cc of 12 volume Dioxogen by 1cc of diluted macerated tissue. Bark tissues are diluted 1–50; leaf and bud tissues, 1–100.

Seasonal Variation in Catalase

The data obtained for the different trees are summarized by grouping the individuals that show similar bearing habits, and the average results for each lot are given. The data are presented graphically in Fig. 1. Turning our attention first to the results secured with the trunk bark, we find that lot A shows a relatively high activity at the end of the 1927 season—the "off" year for this group; a year later the bark tissues from the same lot of trees is much less active due to the heavy crop borne during 1928. Lot C on the other hand shows a low activity at the end of 1927 and a high activity at the end of 1928, the heavy crop occurring during the former year and the light crop during the latter. The trees in lot B are more regular bearers and they show about the same catalase activity at the end of each year.

The difference in activity among the various groups is most marked in spring and fall with relatively little difference in the summer months. The low period is reached in early spring followed by a rapid increase to July and a falling off during August and September.

Catalase activity of the bark of the branches is usually lower than that of the trunk of the same lot of trees, but in general the seasonal variations correspond. The differences are especially marked in

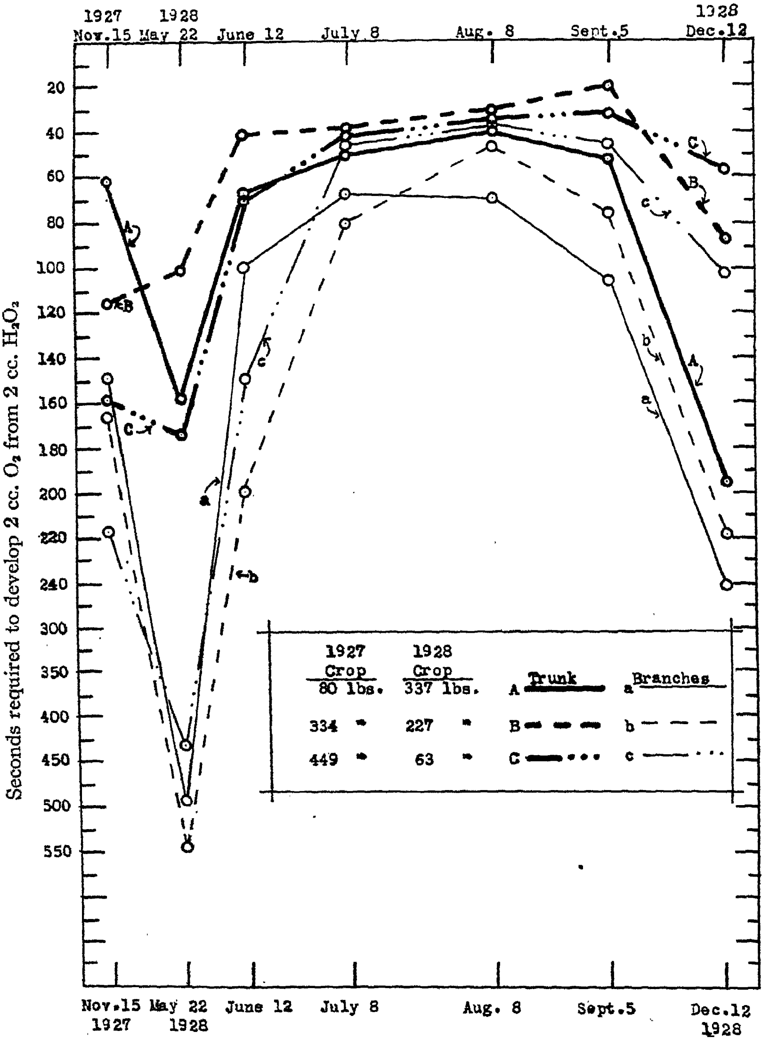


FIG. 1. Seasonal variation in catalase in bark of trunk and branches of McIntosh apple trees. Catalase activity in a given tree is usually less in year of relatively large crop when girth increase is also less. When spread in activity is wide, tree shows alternating tendency; if narrow, tree a regular copper.

spring, even though a few months later trunk and branches may show the same activity, as for example lot C on August 8th. The low point in spring occurs just after the flowers have opened and when new leaves are still appearing—growth processes which greatly

reduce the reserves in the trunk and especially in the branch. The separate branches on a given tree may show marked variations in catalase, but it is apparent that this difference corresponds to the individual growth and fruiting behavior of these units. The bark of the trunk gives the best single sample of the tree since it is a composite of the many branches of the top. If, however, it is desired to study the response of the different parts of the tree, one must rely upon samples from the branches.

In general, the bark from the roots shows a higher activity than the bark from the trunk, but the results in the different trees tend in the same direction, that is, a low catalase activity is found at the end of the heavy crop year and a relatively high activity at the end of the "off" year. The results from root bark for 1927 are: Lot A, 13; Lot B, 15; Lot C, 44 seconds; and for 1928, 49, 21, and 36 seconds, respectively.

The detailed results for the catalase activity of bud and leaf tissues of these trees will be presented at another time. The bud tissues are the most active of any on the tree, a given amount of tissue requiring about one-tenth of the time to do the same work done by the bark when it is most active. Trees showing very low trunk catalase also show relatively low bud catalase. During the winter time the "bud insides" are about one-third more active than the entire buds. If we compare this active tissue only, i.e., the bud minus the scales, we find a retardation in activity from early summer to late winter. Leaf tissue varies considerably in catalase activity depending upon such elusive factors as the temperature during the preceding night, the amount of light, not only during the day when the tests are being made, but also for several days preceding. Great care must be exercised in comparing results of leaf activity taken at different times.

Catalase of the Trunk and Branches at Different Times of the Year

In Fig. 2 the data for individual trees are plotted in the order of the average girth increase during 1927 and 1928. Circumference of the tree trunks at the beginning of 1927, the yield for the two years, and the catalase for the bark of the trunk at the end of the seasons is also recorded for corresponding trees.

As others have shown, there seems to be a fair relationship between the circumference of the trunk and the total crop borne during the biennial period. It will be observed that the girth increase is always greater during the year of the smaller crop, but the difference between succeeding years' growth is not necessarily in relation to the size of the crop and varies with individual trees.

Turning our attention to the catalase, we find that for each tree the activity is usually greater in the "off" year than in the "on" year. The trees which show a relatively good increase in circumference also show a relatively high catalase activity, as for example H 19, H 20, J 16, A 6 and those showing a relatively poor gain also show a low catalase activity. When the average rate of increase is very low the average catalase is also low.

In the "on" year, catalase activity is not always reduced as much as is the girth, as for example H 20, H 19, and sometimes it suffers greater reduction, as for example L 5 and A 5. When the catalase

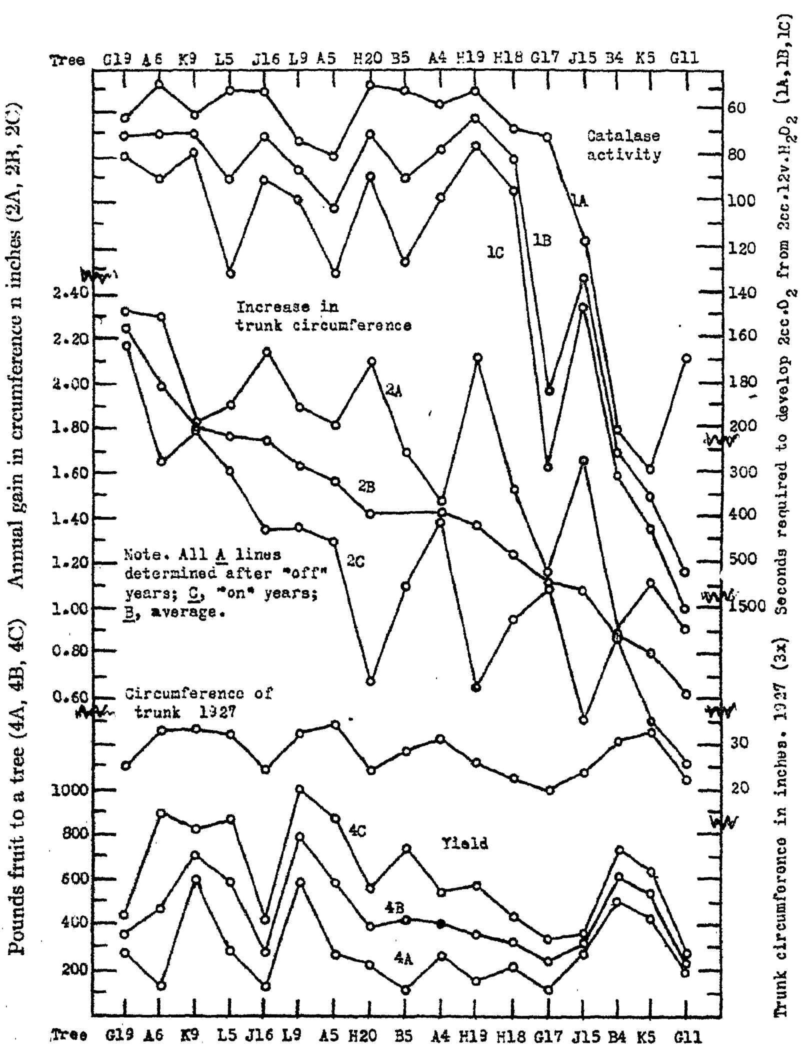


FIG. 2. Catalase activity of trunk, girth, and yield in McIntosh apple trees.

activity is about the same year after year, as in K 9, L 9, J15, K5, G19, the trees tend to be fairly uniform bearers; but when the spread is wide, as in A 6, L 5, A 5, and B 5, there is a tendency for the trees to show a marked alternation.

Evidently, a given crop may exhaust a tree more one year than the next and one tree far more than it does another. This depends somewhat upon the original size of the tree, and, no doubt, also on the relationship between number of vegetative spurs, the number of fruits, the proportion of flowering and fruiting spurs, and other factors. In the spring of 1928 tree No. L 9, for example, showed an average of 214 terminal growing points on 2 representative branches each 10 cm. in diameter. Flowers were produced on 18 per cent of the spurs, and fruits on 12.7 per cent. On similar branches tree No. J 16 produced an average of 202 spurs, 90 per cent of which had flowers and 5.9 per cent fruit.

It is important to know the degree of exhaustion which is caused by a crop, since this will markedly influence the response the following season to the various cultural treatments. Unless we know for each individual tree what the condition is we shall be working in the dark to a considerable extent. The results obtained thus far seem to justify the expectation that catalase eventually will serve as a method of diagnosis which, in a vague manner corresponds to such indicators of metabolism as temperature and pulse rate in the human. These methods, of course, do not tell us all that we need to know, but they give indications which can be checked easily and at frequent intervals if necessary.

Literature Cited

1. Heinicke, Arthur John. Catalase activity in dormant apple twigs: its relation to the condition of the tissues, respiration and other factors. Cornell Univ. Agr. Expt. Sta. Memoir 74. 1924.

Characteristics of Growth and Fruiting in the Baldwin Apple

By L. R. Tucker and G. F. Potter, *University of New Hampshire, Durham, N. H.*

DURING 1927 a study was made at the New Hampshire Station of the characteristics of growth of the Baldwin variety with special reference to the development and functioning of fruiting wood. It is believed that information of this sort is fundamental to a solution of the problem of correcting or partially correcting the biennial bearing tendency and that it may also lead to a better understanding of responses of the tree to practices such as fertilization and pruning. The variety Baldwin was chosen because it is at present the leading commercial variety in this section and because it is the variety with which most of the studies upon fruit bud formation at this station have been conducted. The trees were about 35 years of age, growing in an orchard favorably situated and well fertilized. The average annual terminal twig growth was over ten inches in two of the six years under observations and varied from 4½ to 6 in the other four seasons. They are pruned moderately annually by thinning out and by removing the weakest wood. In this orchard, most of the trees bear fruit every year, although not on the same branches as will be shown later.

The main study was based upon a critical examination of the last six years' growth on 100 branches chosen to represent the various parts of the bearing surface of twenty trees. The growth in each year, 1922 to 1927, of the terminals and laterals was measured, the number of buds formed was counted, and the development of each into spurs or laterals was traced. A record was also made of each blossom cluster produced during this period both on spurs and on laterals or terminals.

One of the most striking facts brought out by this data is that with this variety a very large proportion or even a majority of the buds produced remained permanently dormant. In fact, on the average only from one-quarter to one-half of the buds develop. As might be expected, the buds near the base of each year's growth are least likely to grow. If the shoot is divided into five sections, each containing an equal number of buds, it is found that the proportion of buds developing is greatest in the section just below the tip. There, on the average, about 70 per cent of the buds were found to grow. The percentage of buds which develop falls off in the tip section and progressively in each section toward the base. In very long shoots which produce 18 or 20 buds there is sometimes a zone of dormant buds near the middle of the season's growth. More of the buds grow on long than on short shoots. It was found that on shoots with 16 to 20 or more buds, 50 per cent or more develop, but on shoots with 5 buds or less, less than 2 per cent were found to grow.

In classifying the growths from these buds the usual arbitrary standard was adopted of considering growths of ten centimeters or less to be spurs while longer growths were classified as shoots or laterals. On this basis the growth from any one bud might be a spur one season and a shoot the next. To avoid complications the growth was called a lateral for the whole period if in any one season it grew 10 centimeters or more. Using this basis it was found that during the first year practically all of the buds which grew produced spur growths. Only one bud out of 1039 observed on wood of 1926, produced a growth in 1927, long enough to be classified as a lateral. This was true in spite of the fact that growth conditions in 1927 were very favorable and the average growth for all terminals and laterals was greatest in that season. As they grow older an increasing proportion of these spurs throw out vigorous shoots which are classified as laterals. This is very typical of the Baldwin in this locality. Here and there a spur suddenly becomes very vigorous and produces a long shoot on which in due season more spurs are produced. On wood four or five years old about 12 per cent of all growths were found to be in the lateral class. Such growths often become more vigorous than the axis from which they spring.

The chief interest of course centers on the fruit spurs. There were on the 100 limbs studied 2428 growths which were classified as spurs and which were living in 1927. Six hundred of these were formed in 1923 on wood of the previous season. These spurs then had a possibility of blossoming in four different seasons from 1924 to 1927. There would have been a total of 2400 blossom clusters, if each spur

had bloomed every year. If, in a similar way, the total potential number of blossom clusters be calculated for the whole 2428 spurs, it is found that a 100 per cent bloom for the whole period would have resulted in nearly 6000 blossom clusters. Actually, however, only a little more than 700 were produced, or on the average 12.1 per cent of these spurs produced blossoms. It is well known that the Baldwin spur rarely, if ever, produces bloom in two successive seasons. If non-bearing spurs only are considered it is found that these produced an average of 12.9 per cent of bloom for the period under observation. This is an astonishingly low proportion. A rather large proportion of the spurs seems to remain continuously unfruitful. Of the 600 spurs which had reached five years of age when the study was made, about 49 per cent had not produced a flower during the entire period. Data on blossom production by these spurs are given in Table I.

TABLE I—FRUTING OF BALDWIN SPURS DURING AND PRIOR TO 1927

Year of Origin of Wood Bearing Spurs	Living Spurs Total Number	Per cent Fruiting	
		Once	Twice
1925	694	3.17	
1924	545	13.39	
1923	589	35.48	3.40
1922	600	40.17	11.00

Two-year-old spurs are much less fruitful than older ones. In other words, it is not usual for the Baldwin spur to produce a flower embryo in the same season that it originates. The greatest proportion form their flower embryos when the spur is in its third season of growth and accordingly produce fruit at four years of age. Those which fruit at 2 years apparently repeat at 4 years, and similarly those which fruit at three years seem likely to fruit again at five years of age. This is indicated by the similarity in the proportion of four- and five-year-old spurs which fruit twice to the number of two- and three-year spurs which fruit once.

The work of Roberts (7), Auchter and Shrader (1), Hooker and Bradford (3), Dorsey and Knowlton (2), Mack (4, 5) and Mecartney (6), has covered thoroughly the field of the relation of length-growth of spurs to fruit bud formation. It appears on the whole that while with biennial varieties spur growth is greatest in the off-year, which is the same year that fruit buds are formed, even those non-bearing spurs which make good growth are not likely to form flower embryos during the year of heavy crop. Accordingly, the labor of measuring annual spur growth in this investigation appeared to promise little information and was not undertaken. The records of fruit production terminally on laterals indicate, however, that these, while relatively few in number, on a percentage basis were as fruitful as the spurs. There is no falling off in flower formation when the season's growth is more than 10 centimeters.

Although no measurements of spurs were attempted, an effort was made to correlate the function of spurs on two- and three-year-old

wood, with the type of terminal shoot produced. For this purpose the length and diameter of the shoot growth in 1926 was measured on 1000 terminals on Baldwin trees partly in the same orchard in which the study just described was made and partly in another orchard known to bear large and regular crops. It was felt that these spurs being upon the same axis as the shoot would be subject in large measure to the same nutritional conditions which determine the character of shoot growth. The data are given in Table II.

TABLE II—RELATION OF FRUIT PRODUCTION IN 1926 TO GROWTH CHARACTERISTICS OF THE TERMINAL SHOOTS AND FRUIT BUD FORMATION ON FOUR-YEAR-OLD BALDWIN BRANCHES.

Classification of Branches According to Fruit Production in 1926	Average Length of Shoots in Inches	Average Diameter of Shoots in Inches	Per cent of Non-Fruiting Spurs Forming Fruit Buds
Fruiting limbs	6.73± .21	0.154±0.002	5.96±0.85
Non-fruiting limbs on fruiting trees	3.92± .084	0.142±0.001	22.0 ±0.89
Non-fruiting limbs from non-fruiting trees only	2.71± .076	0.138±0.001	55.03±1.25
All limbs from all trees	4.15±0.72	0.143±0.003	26.2 ±0.73

It was found in summarizing these data that the dominant influence appeared to be the presence of fruit on some of the spurs during 1926, the season that the shoots were growing, and that the flower embryos were being formed in the remaining spurs. The season of 1926 was not favorable to long shoot growth, hence the terminal growths in all cases are rather small. The data indicate that the terminal growth was greatest both in length and diameter on fruiting limbs, next greatest on limbs which did not fruit but which were borne on fruiting trees, and least on the branches of non-fruiting trees. This situation has previously been observed by Mack (5). There appears to be some basis for believing that accumulation of carbohydrates may retard growth. Since the Baldwin produces a large number of spurs, each of which must contribute carbohydrates to the store in the tree, it seems possible that accumulation of carbohydrate in years when there is no crop to utilize it retards shoot growth.

Fruit bud formation, however, was in just the reverse proportion, varying from about 6 per cent on fruiting limbs to 55 per cent in the spurs on the limbs of non-fruiting trees. An attempt was made to study the relation of growth to fruiting and the relation of growth to fruiting and the relation of fruit bud formation to growth by means of correlation coefficients, but the data are not wholly satisfactory because the distributions are not linear. These seem to indicate, however, that in spite of the fact that the twigs on fruiting limbs which produced the smallest proportion of fruit buds were greatest in diameter, there is a tendency for the spurs on branches with shoots of similar length to produce more flower buds when the terminal shoot is of relatively large diameter. When the shoots are classified according to length it is found that the shorter shoots have

highest fruit bud formation, probably owing to the fact that production of fruit on adjacent spurs tends to reduce fruit bud formation and to increase the terminal growth.

The Baldwin is notoriously a biennial bearing variety. Since fruit production was accurately recorded for four seasons on the 100 unit limbs in the study first described in this paper, each of these limbs had three opportunities to produce fruit in two successive seasons by alternation of spurs. Such fruiting in successive seasons was observed only in 19 cases out of a possible 300. There is a decided tendency for all the spurs to form flowers in the same season although the unit is a large one, the main six-year-old axis having in many cases two or three large laterals, the spurs on one of which might well alternate with the spurs of another. These observations indicate very clearly that a Baldwin spur has a decided tendency not to produce flower buds if fruit is being borne anywhere in its immediate vicinity. It has been suggested that over-blossoming is one of the primary causes of alternate bearing but it does not seem likely, considering the small proportion of bloom produced by Baldwin, that this is the fundamental cause for this variety.

Literature Cited

1. Auchter, E. C., and Schrader, A. L. Fruit spur growth and fruit bud production. Proc. Amer. Soc. Hort. Sci., 127–144. 1923.
2. Dorsey, M. J., and Knowlton, H. E. The relation of growth to fruitfulness in some varieties of apples. Amer. Soc. Hort. Sci. Proc., 161–72. 1925.
3. Hooker, H. D., and Bradford, F. C. Localization of the factors determining fruit bud formation. Mo. Agr. Exp. Sta. Res. Bul. 47:1–19. 1921.
4. Mack, W. B. The study of bearing habit of apple varieties. Proc. Amer. Soc. Hort. Sci., 163–173. 1922.
5. ———. Habits of growth and bearing of apple varieties as related to biennial bearing. Proc. Amer. Soc. Hort. Sci., 296–300. 1924.
6. Mecartney, L. J. Relation of spur growth to blossom and fruit production in the Wagener apple. Amer. Soc. Hort. Sci. Proc., 126–133. 1925.
7. Roberts, R. H. Off-year apple bearing. Wis. Agr. Exp. Sta. Bul. 317. 1920.

The Correlation of Trunk Measurements with Tree Performance in Apples.*

R. H. SUDDS and R. D. ANTHONY, *Pennsylvania State College, State College, Pennsylvania.*

IN research in the orchard, it is always a problem what measurements should be obtained and what measurements can be taken with the time and labor available. Yield is, of course, the ultimate criterion but many experiments deal with tree vigor, frequently during the non-productive period of the life of the tree. In other experiments, variables beyond the control of the experimenter sometimes influence yield without correspondingly influencing growth. Thus it is highly desirable to know the relationships which exist between readily measurable tree characters and other measurements equally desirable but which must be secured in a much more laborious manner. The general relation of growth characters to yield is unquestionably of prime importance.

Waring, in the Proceedings of this Society for 1920, gave the coefficient of correlation of yield to circumference increase for a considerable number of experiments, usually for ten-year periods, in various parts of Pennsylvania. In general, this correlation was between .55 and .75, tho in a few cases it dropped as low as .30. At the same time, he reported the coefficient of variability for yield to be in the neighborhood of twice as high as the coefficient of variability for circumference, a fact which would lead us not to expect very high correlation of yield with any growth character. Waring also stated that the use of nitrogen (chiefly on sod trees) lessened the degree of correlation of yield to circumference.

Since the publication of Waring's paper, the Department of Horticulture at the Pennsylvania State College has placed considerable reliance on circumference measurements in interpreting experiments in bearing apple orchards. Because of this, it seemed desirable to check the correlation between circumference and yield in the College orchard with twenty-year-old trees under a wide range of treatments, where each treatment had been maintained, in most instances, since the trees were planted.

While these correlations were being prepared, it was seen in a number of cases that when the yield classes were averaged and the averages plotted against circumferences, they did not fall along a straight line but along a curve which suggested that yield might vary with some power of the trunk circumference. If we consider yield as associated chiefly with tree volume, there would be reason for the use of the cube; on the other hand, if yield is more closely related to branch elongation during the immediately preceding years, the square of the circumference increase might give a better relation.

The mathematical ability of the authors was not sufficiently profound to prove which of these cases most nearly fitted the available

*Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 469.

material. Upon trial it was found that there was very little difference in the correlation when either the square or cube was used, but that either gave somewhat higher values in most cases than the simple circumference. As the square was being used in some other tabulations, it was arbitrarily selected here also.

TABLE I—CORRELATION OF YIELD TO THE SQUARE OF THE TRUNK CIRCUMFERENCE

Treatment	York			Stayman		
	No. Trees	r	Total Mean Yield, Lbs.	No. Trees	r	Total Mean Yield, Lbs.
Sod + nitrogen (10 years)......	27	.76±.055	1476	24	.69±.070	1560
Cultivation + cover crop, no fertilizer	11	.79±.075	1635	14	.68±.095	2595
Cultivation + non-legume cover, no nitrogen.....	22	.65±.090	2757	18	.72±.075	2640
Cultivation + non-legume cover + nitrogen........	21	.66±.085	2769	25	.46±.115	3135
Cultivation + legume cover, no fertilizer.....	18	.60±.100	2715	20	.68±.080	3015
Cultivation + non-legume cover, no fertilizer.....	15	.22±.165	3650*	14	.56±.125	2442

*Receives considerable wash from manure and NPK plots above it.

At least twice in the history of this orchard the blossoms have been considerably injured by frost. Even under these conditions the correlations show that the circumference records are a desirable adjunct to yield records. The table also seems to agree with Waring that the addition of nitrogen, either from the fertilizer sack or by soil washing, decreases the correlation.

In the same orchard with the trees reported in Table I, a block of Stayman and York trees was studied by measuring the approximate spread and height of each tree and computing a theoretical volume. This was correlated to trunk circumference. Stayman gave a correlation of .57 ± .08 with a coefficient of variability of 15%; York gave a correlation of .54 ± .087 with a coefficient of variability of 12%. When these same tree volumes were correlated to either the square or the cube of the circumference, there was either no significant change or else there was a loss in the correlation.

The previous records have dealt with trees which have reached nearly full maturity. In one experiment, trees receiving different fertilizer treatments were grown with the roots confined by large iron cylinders. Twenty-eight trees were grown for seven years and fourteen trees for six years. The trees receiving nitrogen had come into full bearing when the experiment was completed. At that time all the scaffold branches and leaders were removed and the total weight of each and the circumference 5 cms. above the base taken. Branch elongations had previously been recorded for each year. Six trees received the same fertilizer treatment, three of them under sod

and three under cultivation. As some of the fertilized trees had tops over five times as heavy as the check trees in sod, there was a considerable range in weight, branch elongation and circumference.

In the 1921 Proceedings of this Society, Heinicke reports that with four-year McIntosh the correlation between circumference and tree weight was such that doubling the circumference increased the weight 7.3 times. This suggests the cubical parabola. In our own results when the weight of these branches was correlated to the circumference by groups of three trees which had received similar treatment, this same tendency of weights to follow a curve rather than a straight line was evident. For this reason, weight was plotted against the cube of the circumference. This had the effect of increasing the correlation somewhat over that obtained with the simple circumference.

Twelve of the fourteen groups of three trees each had a correlation of branch circumference cubed to weight of better than .95 ± .013 and the lowest was .898 ± .025. No influence of the treatment upon the correlation could be detected. The correlation of the trunk circumference of these 42 trees to the weight of the entire top was .92 ± .017.

Excluding the spurs, the total length of growth of each scaffold branch and leader during 1927 was correlated to the circumference cubed. When growth was normal, as with the trees receiving nitrogen or even with those not receiving nitrogen but under cultivation with a cover crop, the correlations were high, generally above .85 ± .035. But when growth became stunted, as in the check trees under sod, elongation increased more in proportion than circumference and the correlation dropped. In the check sod trees, it was .28 ± .13. When the total branch elongation since planting of each of the forty-two trees was correlated to trunk circumference cubed, the coefficient of correlation was .94 ± .01.

In still another experiment at the College, an orchard of Stayman was planted in the spring of 1927; part of the trees were budded on commercial seedlings and part on a clone root. Measurements were taken both at planting and again at the end of the second growing season. The 119 trees on the usual nursery roots were much more carefully selected for uniformity at planting than the 98 on the clone roots. In spite of this, the correlation of the former for the diameter to the weight at planting was .75 ±.027 and of the latter .77 ±.028, —a negligible difference.

It was a considerable surprise that neither weight nor height at planting showed any certain correlation to branch elongation two years later. The correlation of the square of the circumference increase during 1927 and 1928 to the branch elongation during 1928 was better than .75 ± .03 for both groups of root stocks.

The conclusions from these studies are that trunk circumference or circumference increase records are so valuable an addition to apple yield records that they should be included in most orchard experiments where yield is the criterion; and that trunk and branch circumference are so closely correlated to weight and elongation that usually they are the only records which need be taken in studies involving apple tree vigor.

Correlations Between Growth and Fruit Production of Apricots

H. S. REED, *Citrus Experiment Station, Riverside, California.*

THESE records are taken from the results of a pruning experiment carried out on a four-acre orchard of Royal apricots. Reports on the growth of these trees have been published (1, 2, 3) and form part of a study which attempts to analyze the growth process of this tree.

The trees were planted in 1916 and have grown satisfactorily. There are 10 plots of 20 trees consisting of 4 sub-plots of 5 trees each. The first fruit was produced in 1919, but no computations on it were made. The nine succeeding crops of fruit have been studied. The soil of the orchard has been irrigated in conformity with good practice in this locality. Table I shows the amount of water applied each year, the average production in pounds of ungraded fruit per year, and the average increase in the area of cross-section of the trunks computed from the circumference at a marked place.

TABLE I—GROWTH AND YIELDS OF APRICOT TREES

Year	Acre Inches of Water Applied	Yields per Tree in Pounds	Increase in Area of Cross Section in Sq. Cm.
1920	24.04	44	118
1921	22.45	92	46
1922	22.75	194	21
1923	26.00	34	45
1924	40.27	108	36
1925	51.26	148	27
1926	31.47	73	30
1927	27.24	195	31
1928	42.88	221	

The point to be investigated at the present time is the interrelationship between the amount of fruit and such variables as increase in size of tree, relative size of fruits, and amount of wood removed at pruning.

The severity of the pruning had a positive effect on the growth of the tree in any given year. The seven coefficients are all positive and rather large, while their probable errors are all less than .05. There seems to be no secular change in the value of the coefficients of gross correlation.

The effect of pruning on the size of fruits shows an interesting secular change. In 1922 smaller fruit was associated with heavy pruning. In the next two years there was no appreciable effect one way or the other, but since then there has been a steady decrease in the value of the coefficients showing that the more wood removed, the larger the fruits. The anomalous result in 1922 may be due in part to the plots of trees which receive "long" pruning. The trees in these plots produced their fruit on slender shoots on the outside of the trees where it was badly sunburned, and consequently under-

sized, in spite of the fact that the wood removed was from 50 to 70 per cent of that removed on trees which were headed back and, as a result, produced their fruit on short spurs in the interior. Since 1923 the fruit on the trees has been thinned and much of that on the slender upper shoots has been removed, making the "long" pruned trees more comparable with the others. When the correlation between amount of wood removed and number of fruit per pound is corrected for the variability in yields, the coefficients are larger and show a less pronounced secular change.

The coefficients representing the correlations between weight of wood removed and yields of fruit have significantly positive values only in three years (1923, 1924, 1925) and even these are not large. Obviously the yield is conditioned upon factors which reside in the lower parts of the tree and are not affected by the pruning of the winter preceding, unless it is so severe that the balance between vegetative and reproductive processes is entirely upset. Further study will be directed toward an investigation of the influence of pruning upon the yield of the next year following.

The growth of the trunk is, to a small extent, associated with the number of fruits per pound. All the coefficients expressing the correlation have negative values, but they are only significant in 1922, 1925, and 1926. Hence we are not warranted in placing much emphasis on the relationship. This is not surprising when we observe that the fruit is harvested the first week in July and that the trees continue to grow for four or five months after that time.

The next series of correlations may seem to contradict our experience when we find that the coefficients expressing the relation between yield and number of fruit per pound is not strikingly positive, but they are significant only four out of seven years. When the crop was very small, as in 1923 and 1926, the correlation might be expected to fail, but it also fails in 1927 when the trees produced a good crop. The case is helped, however, by making the partial correlation. Assuming that the same amount of wood was pruned from each tree, the coefficients for 1923 and 1926 are not materially changed, but the others are increased.

A series of strong positive correlations between growth of the trunk in the preceding year and yield of fruit is shown by the next set of coefficients. Only in case of the 1926 (small) yield was there any lack of significant correlation. This series is quite in harmony with our experience. A tree which makes good growth is usually one which produces fruit the next year. Yields of fruit and increase in size of trunk for the same year do not have very strong correlations, in fact the assemblage of coefficients lacks significance. This raises the question whether the trunk growth of one year is correlated with that of the following year. Further studies on that point are in progress.

Since only 9 crops are available it would be hazardous to correlate yields with such factors as irrigation or rainfall though such infor-

mation is very desirable. We know that the yields of apricots in 1922 and 1928 were large over the entire state, but we do not know the meteorological factors responsible for it. The rainfall of the winter 1921–22 was much above the average but that of 1927–28 was a little less than the average in the Riverside region.

The comparison of the correlation coefficients has yielded information of a character which we believe to be reliable because it gives each tree its proper place in the composite picture.

LITERATURE CITED

1. REED, H. S. The dynamics of a fluctuating grow h rate. Proc. Nat. Acad. Sci., 6:397–410. 1920.
2. ———. Growth and sap concentration. Jour. Agr. Res., 21:81–98. 1921.
3. ———. Growth and correlation in apricot trees. Univ. Calif. Publ. Agr. Sci., 5:1–55. 1924.

Preliminary Report on Relative Vigor of Apple Seedlings*

By J. H. BEAUMONT, *North Carolina Agricultural College,*† *Raleigh, N. C.*

THE trees described here were not planted as an apple stock experiment but rather as an experiment in breeding hardy apples at the University of Minnesota Fruit Breeding Farm, near Excelsior, Minn. The crosses were made in 1919 under the supervision of Dr. M. J. Dorsey. From 1921 to July 1928, the author had supervision of the experiment. The seed were germinated in flats and transplanted to cold frames the first year, transplanted to the nursery and grown one year, and again transplanted to the field in the spring of 1922. The trees were set 4 ft., apart in rows approximately 12 ft. apart. As a detailed breeding analysis of the material was planned an effort was made to save every seedling possible. Consequently, no conscious selection was practiced. Records were kept on the trees from the time they were set in the field and at present the approximate history of every living and dead tree can be given.

The height and trunk diameter measurements on a certain number of these seedlings are reviewed briefly here. No conscious selection has occurred but in the vicinity of St. Paul, winter hardiness and disease, especially ~~blight, missing~~ trees and perhaps other factors may have influenced the results to an extent not yet calculated. Presumably rabbit and mouse injury would be more or less at random. The trees of the different crosses were not planted in solid blocks but rather in numerous small and irregularly sized groups such that in a measure soil variations have been compensated. However, the entire population of a ~~cross was calculated as one group~~.

*The work was done while the author was in charge of the fruit breeding work at the University of Minnesota. The author is indebted to Prof. W. H. Alderman for encouragement and assistance in carrying on the work and to Mr. F. E. Haralson for material assistance in securing some of the data included.

†Published with the approval of the Director as Journal Series Paper No. 831 of the Minnesota Agricultural Experiment Station.

Measurements were made, before growth started one year from setting in the field in 1923, and again in 1924 and 1928. The height was measured with a pole and the trunk diameter with a vernier caliper and read to the closest millimeter. Measurements of trunk diameter were made approximately 1 ft. from the ground and from east to west. There undoubtedly was some error in these measurements as the exact location for subsequent measurements was not fixed. However, the trees were pruned to a single trunk and other than being difficult to crawl under, presented little cause for inaccuracy. From these data the means, S. D's, and C. V's. of H. F. and T. D., height in feet and trunk diameter, respectively, for the three years have been determined and a certain number of correlations between them have been calculated.

Values of Tree Measurements

The coefficients of variability of both T. D. and H. F., are large. (See Table I). The average C. V. of H. F., in 1927–8 is slightly more than 20 per cent. This means that the S. D. is one-fifth the value of the mean and, consequently, that the range and variability are large. For example, a mean of 8 ft. with a S. D. of 1/5 M (1.6 ft.) signifies that 68.3 per cent of the trees are from 6.4 to 9.6 ft., and that the other 31.7 per cent are larger or smaller than this. The absolute ranges are not given but in one case it was from 4 to 15 ft. for a single group.

Without exception the C. V. of the trunk diameter is greater than the C. V. of the height in feet for the year 1928 in any given group, although only four of these show significant differences judging by the P. E.'s in the 17 crosses considered. The more significant differences are as follows:

Differences Between the C. V.'s‡ of H. F. and T. D. Measurements for the Year 1928.

Cross	Diff.	P. E. of the Diff.
Delicious x Duchess	16.41	3.0
Jonathan x Wealthy	13.14	3.4
Grimes x Duchess	13.23	1.9
Okabena x Duchess	10.22	2.5

The smallest difference obtained was 1.57 ± 3.2 in the cross Lady Apple x Wealthy. No differences other than these tabulated would be greater than three times the P. E., of the difference. The four cases mentioned might be considered to indicate a constant difference in the amount and kind of variability in the two characters measured. It will appear that this variability is not necessarily correlated.

The differences between the two sets of measurements have increased since 1923–4, when the first records were taken. The largest difference recorded at the earlier date was 6.98 ± 2.3 in the cross

‡These values may be obtained from Table I.

Delicious x Okabena. The tendency has been for the different groups to become considerably more uniform in height and trunk diameter as the trees increase in age but the trunk diameters lag so much that the differences become greater.

Considering first the decrease in variability in H. F., from 1923–4 to 1927–8 the following significant differences are recorded:

DECREASE IN C. V. OF H. F. FROM 1923–4 TO 1927–8.

Cross	Diff.
Duchess x Grimes	12.7 ± 1.6
King David x Duchess	8.7 ± 1.3
Duchess x King David	8.2 ± 1.9
Grimes x Duchess	8.0 ± 1.6
Jonathan x Duchess	6.1 ± 0.9

These figures were calculated for only 7 of the 17 crosses under consideration but are sufficient to show that the trees tended to become more uniform in height during the five-year period 1923–4 to 1927–8.

The behavior of the trees as measured by the trunk diameters is much less uniform. In the same cross Grimes x Duchess tabulated above there was an increase in variability from 34 to 41 while in the other crosses reduction in variability occurred. The differences are small, however, with two exceptions, the one mentioned where a marked increase occurred and in the cross Duchess x Grimes where the decrease 11.0 ± 1.9 occurred. All other differences are small and in the light of their P. E.'s are of little significance except that a general tendency is indicated.

These data would seem to justify the following conclusions: 1. Six growing seasons after setting, the trees are more uniform, especially in height and in trunk diameter, than they were one year after being set. 2. The height of the trees is more uniform than is their trunk diameter, both after one year from setting and six years from setting. 3. The C. V.'s of height have decreased consistently and significantly as the trees attained greater age while the C. V.'s of trunk diameter have decreased less consistently, there being significant differences in both directions but the general tendency is to become slightly more uniform.

CORRELATION BETWEEN H. F. AND T. D.

A further test of the usability of these two measurements as a measure of vigor is furnished by determining the degree of association between them. Correlation coefficients were calculated between the H. F. and T. D. measurements of three years for four of the crosses as well as between the H. F. and T. D., measurements themselves.

Contrary to expectation, high correlations were not secured except between measurements taken the same year. This is interesting in view of the fact that many investigators have used one or the other of these measurements as an indication of vigor. High corre-

TABLE I

Cross	Total No. Trees Planted 1922	Yr. Records Taken	Trees Dead or No Record	% Trees Dead or No Record	No Trees Measured	Trunk Diameter C. M.			Height in Feet		
						Mean	S. D.	C. V.	Mean	S. D.	C. V.
Black Ben x Duchess. . .	48	1925–6	12	25.0	36	4.657±.119	1.040±.826	22.324±1.8610	8.682±.134	1.192±	13.751±1.114
Grimes x Duchess	350	1923–4	17	4.9	333	.879±.011	.300±.008	34.119± .990	2.349±.042	.848±.029	36.115± .041
		1924–5	45	12.9	305	1.397±.019	.487±.013	34.872±1.062	3.661±.043	1.103±.031	30.131± .895
		1927–8	152	43.4	198	3.199±.063	1.323±.045	41.330±1.441	7.045±.094	1.979±.067	28.096±1.331
Duchess x Grimes	117	1923–4	5		112	.904±.019	.297±.013	32.924±1.637	2.478±.045	.711±.032	28.703±1.384
		1924–5	7		110	1.666±.032	.500±.023	30.007±1.483	8.743±.061	.958±.043	25.606±1.233
		1927–8	24	20.5	93	4.879±.075	1.070±.052	21.924±1.135	8.242±.092	1.319±.065	16.007± .812
King David x Duchess	254	1923–4	11		243	1.047±.014	.317±.010	30.322±1.012	2.889±.038	.887±.027	30.718±1.025
		1924–5	21		233	1.762±.024	.535±.017	30.388±1.034	4.128±.049	1.111±.035	26.905± .898
		1927–8	49	19.3	205	4.611±.061	1.294±.043	28.061±1.006	8.671±.090	1.906±.064	21.988± .767
Duchess x King David	119	1923–4	8		111	.930±.022	.338±.015	36.434±1.855	2.459±.049	.765±.035	31.124±1.539
		1924–5	4		115	1.676±.032	.506±.023	30.164±1.459	4.004±.051	.814±.036	20.341± .941
		1927–28	32	26.9	87	4.427±.095	1.312±.067	29.630±1.643	8.034±.133	1.846±.094	22.951±1.227
Okabena x Duchess	74	1927–8	17	23.0	57	4.233±.120	1.342±.085	31.707±2.195	8.228±.158	1.767±.112	21.478±.418
Okabena x Grimes	88	1927–8	47	53.4	41	4.042±.148	1.408	34.826±2.892	7.927±.206	1.956±.146	24.671± .947

Okabena x Delicious	59	1927–8	3	5.1	56	3.986±.089	.982±.063	24.640±1.663	8.358±.72	1.903±.121	22.777±1.525
Delicious x Okabena	72	1923–4	2		70	.750±.022	.276±.016	29.095±1.793	2.817±.053	.657±.037	23.313±1.389
		1924–5	4		68	1.897±.038	.461±.027	24.316±1.487	4.529±.091	.992±.057	21.910±1.317
		1927–8	8	11.1	64	4.693±.102	1.212±.072	25.828±1.639	8.594±.135	1.598±.095	18.592±1.146
Wealthy x Okabena	86	1927–8	33	38.4	53	4.133±.132	1.420±.093	34.366±2.503	7.264±.170	1.834±.120	25.247±1.756
Duchess x Delicious	339	1923–4	9		330	.996±.011	.282±.007	28.329± .801	2.747±.027	.731±.019	26.618± .747
		1924–5	14		325	1.705±.019	.496±.013	29.075± .832	4.046±.038	1.017±.027	25.143± .703
			87	25.7	282	4.702±.052	1.205±.037	25.618± .836	8.469±.080	1.889±.057	22.310± .703
Delicious x Duchess	35	1927–8	7	20.0	28	4.127±.153	1.200±.108	29.074±2.833	7.714±.125	.977±.088	12.661±1.159
Delicious x Hibernal	36	1927–8	5	13.9	31	4.711±.150	1.236±.106	26.246±2.398	9.177±.220	1.812±.155	19.744±1.756
Jonathan x Duchess*	352	1923–4	6		346	1.017±.102	.282±.007	27.764± .765	2.906±.028	.766±.020	26.362± .721
		1924–5	26		326	1.810±.016	.438±.049	24.177± .675	4.149±.033	.879±.023	21.181± .557
		1927–8	97	27.6	255	4.037±.049	1.147±.033	28.424± .915	8.074±.069	1.635±.049	20.248± .629
Jonathan x Duchess	214	1924–5	13		201	1.331±.017	.347±.012	26.072± .938	3.673±.041	.858±.029	23.363± .828
		1927–8	28	13.1	186	4.160±.048	.981±.034	23.583± .867	8.150±.078	1.576±.054	19.334± .683
Jonathan x Wealthy	68	1927–8	26	38.2	42	3.523±.130	1.250±.092	35.453±2.919	6.762±.157	1.509±.111	22.315±1.722
LadyApple x Wealthy	75	1927–8	46	61.3	29	5.091±.161	1.288±.114	25.291±2.379	7.621±.226	1.808±.160	23.722±2.216

*Set one year later (1923).

TABLE II—CORRELATION BETWEEN HEIGHT FEET AND TRUNK DIAMETER

Cross	r. of H. F. 1923–24 x T. D.			r. of H. F. 1924–5 x T. D.			r. of H. F. 1927–8 x T. D.			r. of H. F. 24–5 x H. F. 27–8	r. of T. D. 24–5 T. D. 27–8
	23–4	24–5	27–8	23–4	24–5	27–8	23–4	24–5	27–8		
Duchess x Grimes.	.696+.033	.649+.038	.396+.034	.430+.053	.698+.033	.405+.059	.294+.065	.552+.049	.721+.034	.491+.053	.687+.037
Grimes x Duchess.	.711+.018	.674+.021	.462+.038	.446+.046	.758+.016	.571+.033	.309+.046	.579+.033	.829+.015	.607+.031	.714+.024
Duchess x King D.	.797+.023	.625+.040	.244+.070	.687+.034	.707+.032	.305+.065	.100+.072	.608+.046	.750+.032	.396+.061	.502+.054
King D. x Duchess	.772+.018	.604+.029	.333+.043	.525+.033	.739+.020	.530+.035	.329+.043	.666+.027	.766+.019	.891+.010	.732+.037

lations were expected because it would naturally be assumed that a large diameter tree or a tall tree would tend to remain tall or large and that a tall tree would tend to have a large diameter due to its inherited capacity for growth and, perhaps, also to its favorable location, neither of which would change materially from year to year. High correlations are necessary if they are to be of great significance as a basis for prediction. Unfortunately regression constants were not determined but by using the formula used by Ritchie (1) a convenient means of estimating the value of the correlation coefficient is secured. By this formula may be calculated the per cent of the total variability that is a function of the factors considered. In other words, a correlation of .8 means that 40 per cent of the total variability has been accounted for and that the remainder, or 60 per cent, is due to unknown causes.

Considering now the correlations between H. F. and T. D., in the spring 1924, one year after being set, the correlation between H. F. and T. D., for the crosses Duchess x Grimes, Grimes x Duchess, Duchess x King David, and King David x Duchess were r = .69, .71, .79, and .77, respectively. Thus less than 40 per cent of the total variability is a function of characters considered. This is true for other years as well.

The correlations between the H. F., in 1923–4 and the T. D., in 1927–8 for the same four crosses respectively are as follows: r = .39, r = .46, r = .24, and r = .33. While these correlations are significant in the light of their P. E.'s, obviously these characters while correlated are not sufficiently so to give a basis of prediction as to the behavior of one with relation to the other after four additional growing seasons. The same fact is emphasized by considering the converse correlations, i.e., H. F. 1927–8 and T. D., 1923–4. Apparently, the height of the tree in 1927–8 bears practically no relation to what the trunk diameter was in 1923–24.

The H. F. or the T. D., of one year is more directly correlated with the same character another year. These r's are higher than those between T. D. and H. F., but even here, considering the age and type of the material, it would be unsafe to place great reliance on a prediction that the character would be relatively constant. However, judging by the latter two sets of r's, it appears that the r's between the T. D.'s are more valuable than those between the H. F.'s as a basis of prediction as to what the future condition of the character will be. For example, a small diameter tree will more likely remain small than will a short tree remain short.

It may be worth while to mention that the smaller r's in all cases including the H. F. x T. D. combinations, with few exceptions, are with the Duchess female while the larger are with reciprocals. What the significance of this may be is conjectural until additional data has been calculated. It would seem to indicate a difference in reciprocal crosses that is also emphasized by later data.

It may be concluded from these correlations that: (1) Neither the H. F. nor the T. D., gives a safe criterion as to what the opposite character will be five years later; (2) in a given year the H. F. and

T. D.'s seem to be fairly closely associated; (3) the T. D. is more highly correlated with the T. D. of following and preceding years than is the H. F. and, therefore, is a more constant character; (4) Both the female parent and its male complement, apparently, exert independently a marked influence on the character and behavior of the seedlings such that the same measurement may not be of equal value on all groups, and (5) neither measurement nor, in fact, both measurements, would seem to be the only one or ones that must be considered if the probable vigor of a tree is to be predicted from early analyses.

Comparisons of Specific Crosses

We have shown that there is a fair correlation between T. D. and H. F. measurements of a single year. Therefore, this would seem to be the only way to compare specific crosses. In view of the poor correlations between the measurements of earlier with those of later years the later measurements have been chosen as a basis for comparison and, presumably, either T. D. or H. F. will serve, even though the T. D. is 5 to 10 per cent more variable.

Table III gives the essential data covering the condition of the trees, in spring of 1928, of about 18 crosses. The crosses are grouped according to a common parent in each. This makes for a certain amount of duplication but allows for convenient comparisons. The line through a common parent group merely sets off the crosses of the common parent as a male and as a female. The total number of trees planted in 1922 is given and in the next column the percentage of trees having died or on which no records were taken for various reasons. In the last two columns the C. V. of height and the mean height are given.

After this table was made the need for a check was evident. Consequently, two groups of open-pollinated seedlings, King David and McIntosh, having 120 and 132 seedlings, respectively, were calculated. If these had been combined with several other such groups a better check of its kind would probably have been obtained. Another check, and a more useful one, would be a pure line or a clone of some kind that would exhibit no genetic variability and, consequently, would be a measure of variation in soil, treatment, etc. However, if these were available there would probably be no stock problem in apples. All that our present checks indicate is that the open-pollinated groups are significantly more variable in H. F. and T. D., than any single group of seedlings except that of Grimes x Duchess. They are also somewhat shorter than the average. The constants are:

Cross	C. V. of H. F.	M. of H. F.
King David	31.84 ± 1.7	7.63 ± .17
McIntosh	32.79 ± 1.9	7.36 ± .17

In Table III, under Duchess, common parent, Grimes X Duchess is the poorest combination. The mortality is very large, the C. V. is greatest of any group in the whole table and the trees average more than a foot shorter than any other combination in the Duchess group.

This combination seems to be inherently weak. Okabena x Grimes also seems to be quite poor, making two combinations with Grimes that are weak. However, in Duchess x Grimes, the reciprocal of the first cross, the trees are among the most uniform, are of average height and the mortality among the seedlings is below the average. We cannot account for this difference in a reciprocal cross as yet.

TABLE III—COMPARISON OF CROSSES ON THE BASIS OF THE H. F. MEASUREMENTS OF 1928

Common Parent	Cross	Total No. Trees Planted 1922	Per cent Trees Dead or No Record 1928	C. V. of Height Feet 1928	Mean Height 1928
Duchess	Black Ben x Duchess	36	25.0	13.7514±1.114	8.6806±.134
	Grimes x Duchess	350	43.4	28.0965±1.331	7.045 ±.094
	King David x Duchess	254	19.3	21.9878± .767	8.671 ±.090
	Okabena x Duchess	74	23.0	21.4776±1.418	8.228 ±.158
	Delicious x Duchess	35	20.0	12.6609±1.159	7.714 ±.125
	Jonathan x Duchess	352	27.6	20.2477± .629	8.075 ±.069
	Jonathan x Duchess*	214	13.1	19.3338± .683	8.151 ±.078
	Duchess x Grimes	117	20.5	16.0072± .812	8.242 ±.092
	Duchess x KingDavid	119	26.9	22.9513±1.227	8.0341±.134
	Duchess x Delicious	339	25.7	22.3103± .703	8.468 ±.080
Okabena	Delicious x Okabena	72	11.1	18.5925±1.146	8.594 ±.135
	Wealthy x Okabena	86	38.4	25.2471±1.756	7.264 ±.170
	Okabena x Duchess	74	23.0	21.4776±1.418	8.228 ±.158
	Okabena x Grimes	88	53.4	24.6707±1.947	7.927 ±.206
	Okabena x Delicious	59	5.1	22.7770±1.525	8.357 ±.172
Delicious	Okabena x Delicious	59	5.1	22.7770±1.525	8.357 ±.172
	Duchess x Delicious	339	25.7	22.3103± .703	8.468 ±.080
	Delicious x Okabena	72	11.1	18.5925±1.146	8.594 ±.135
	Delicious x Duchess	35	20.0	12.6609±1.159	7.714 ±.125
	Delicious x Hibernal	36	13.9	19.7442±1.756	9.177 ±.220
Grimes	Grimes x Duchess	350	43.4	28.0965±1.331	7.045 ±.094
	Duchess x Grimes	117	20.5	16.0072± .812	8.242 ±.092
	Okabena x Grimes	88	53.4	24.6707±1.947	7.927 ±.206
Wealthy	Jonathan x Wealthy	68	38.2	22.3147±1.722	6.762 ±.157
	Lady Apple x Wealthy	75	61.3	23.7222±2.216	7.6207±.226
	Wealthy x Okabena	86	38.4	25.2471±1.756	7.264 ±.170
Jonathan	Jonathan x Wealthy	68	38.2	22.3147±1.722	6.7619±.157
	Jonathan x Duchess	352	27.6	20.2477± .629	8.075 ±.069
	Jonathan x Duchess*	214	13.1	19.3338± .683	8.151 ±.078

*Set one year later (1923).

The best combination with Duchess is the first, Black Ben x Duchess. The mortality is above the average but the trees are among the most uniform and are next to the tallest of the whole group. The C. V. of T. D. is also among the lowest of any group. Another good combination is King David x Duchess, for the mortal-

ity is low, and the trees were very tall even though the trees were more variable than those of the Black Ben cross. Thus it is seen that with Duchess as a common parent and, consequently, all the crosses constant in this respect, very good to very poor groups are obtained, depending on the opposite parent and also on the way in which the cross is made.

Okabena x Delicious is the best in the Okabena group from the standpoint of mortality, uniformity, and average vigor, although the reciprocal is also good and even more uniform. Grimes as a male parent is poor with Okabena.

Delicious as a male and female parent seems to be uniformly better than any other parent. It seems to be especially good as a female. Note the low mortality, low variability and large size of Delicious with Okabena and Hibernal. This group, Delicious x Hibernal, has given the largest group of seedlings of all the crosses.

To test whether Hibernal was particularly prepotent as a male parent another cross was calculated—Jonathan x Hibernal. The Mean of this group was 6.2′ and the C. V. 23. Thus Hibernal would seem to carry those growth factors required to stimulate growth of Delicious seedlings but not those of Jonathan. Instances such as this are frequent in the whole table.

Wealthy both as a male and as a female parent, judging by the three crosses calculated, carries weakness. Consider the high mortality, high variability and small size.

Thus it is again emphasized that seedlings stocks are extremely variable, and, also, a condition that is equally important, that the parentage of the stock has a marked influence on its uniformity and vigor.

Literature Cited

1. Hayes, H. K., and Garber, R. J. Breeding crop plants. New York. 1927.

Immediate and Residual Effects of Sodium Nitrate Upon Yield and Growth of McIntosh Apple Trees

By A. B. Burrell, *Cornell University, Ithaca, N. Y.**

IN midsummer 1926, the orchard of Wm. Everett and Son, at Peru, in the Champlain Valley of New York, was below optimum vigor and apparently in need of nitrogenous fertilizers. Preliminary tests with sodium nitrate gave such striking results that the Everett orchard was chosen for further studies with this material with special reference to its residual or hold-over effects upon yield and growth.

The land in this orchard slopes very slightly to the east. The soil is a grayish-brown sandy loam of low organic content, and its fertility is so low that without fertilization it will support only a sparse growth of weeds or sown cover crop. The surface soil is underlaid at depths varying from 15 to 40 inches by a reddish-brown, more or less impervious subsoil. Sometimes the orchard is plowed in the spring, sometimes not, but in either case, it is usually disked in two directions about three times during the season, leaving a clump of grass around the trunk of each tree. The first cultivation is given as early in the spring as the ground can be worked, which is usually before the blossom buds have separated in the cluster, and the last in the latter part of June. In 1928, the soil was so wet throughout the spring and early summer that it was disked just once before bloom and once after.

A row of 16-year-old McIntosh trees was selected for the present work, and the trees were numbered consecutively from 1 to 24. Tree 3 was discarded because it proved to be of another variety. In midsummer 1926, the trees were clearly below optimum vigor and about uniform in condition. They were carrying a light crop which was fairly evenly distributed among the different trees. In Table I, the figures for terminal growth in 1925 and 1926 give some indication of the vigor of the trees prior to treatments. The girth of each tree in September 1927 furnishes a rough measure of its size, but since at this date the nitrated trees had already received large benefits from the treatments, the checks are at a relative disadvantage in the girth figures. Cultural practices other than the use of sodium nitrate have been similar throughout the experimental row. The adjacent row of trees on the east is of the variety Wealthy, and on the west, Fameuse. The proximity of these other varieties and the fact that the owner keeps bees, decrease the danger of complications due to lack of cross-pollination.

Sodium nitrate was applied to certain trees (1) after the terminal buds had formed in midsummer 1926, (2) at an early green-tip stage in the spring of 1927, and (3) at an early green tip stage in 1928. The material was broadcast by hand on the tree circle in the usual way.

*Helpful suggestions of Dr. A. J. Heinicke during the preparation of this paper are gratefully acknowledged.

The data as presented in Table I are on the basis of individual trees, in terms of yield, elongation of terminal twigs, and elongation of lateral shoots from terminal twigs. In 1927, a representative terminal was selected by inspection on each of the four sides of every tree The figures in Table I for average elongation of terminal twigs in 1925, 1926, and 1927, are based on these 4 terminals per tree. The figures for elongation of lateral shoots in 1927 are also based on these 4 terminals. Only lateral shoots that elongated 2 inches or more in 1927, and originated within 2 feet of the base of the 1927 terminal growth, are included. The procedure in 1928 was identical except that 8 terminals instead of 4, were used.

Responses to Sodium Nitrate

In 1927, all even-numbered trees from 7 to 24 had, during the experiment, received sodium nitrate while all the odd-numbered trees in this part of the row were checks. The nitrated trees bore about 4 times as much fruit as the checks, the poorest nitrated tree having a higher yield than the best check. In 1928, the average yield of all nitrated trees in this part of the row was about 2½ times that of the checks. Only one check exceeded the poorest nitrated tree, and each nitrated tree was superior to the nearest check.

Trees 7 to 12 inclusive, in 1927, illustrate the second-year effect of a single application. Trees 8, 10, and 12, which received nitrate in midsummer 1926, bore about 3 times as much fruit as the adjacent untreated trees, 7, 9, and 11, the poorest nitrated tree being superior to the best check.

Trees 9 to 12, inclusive, in 1928, illustrate the third-year effect of this single application. Trees 10 and 12, which received nitrate only in midsummer 1926, bore about 1½ times as much fruit as check trees 9 and 11, the poorer nitrated tree being slightly superior to the better check.

Trees 13 to 16 inclusive, in 1928, illustrate the residual effect of two applications. Trees 14 and 16, which received nitrate in 1926, and 1927, but not in 1928, bore about 2½ times as much fruit as check trees 13 and 15. The poorer nitrated tree was slightly superior to the better check.

Trees 18 and 20, with both the residual effect of the 1926 and 1927 applications plus the 1928 application, bore about 1½ times as much fruit in 1928 as trees 17 and 19, which had only the 1928 application.

The foregoing comparisons have been between adjacent trees and are considered fairly reliable. Confirmatory suggestions may be derived from a few comparisons of trees somewhat separated from each other.

In 1928, trees 10 and 12, with only the residual effect of the midsummer 1926 application, bore about the same amount of fruit as trees 17 and 19 with the first-year effect of the 1928 application. Trees 14 and 16, with only the residual effect of two applications, yielded slightly more than trees 17 and 19.

TABLE I—IMMEDIATE AND RESIDUAL EFFECTS OF SODIUM NITRATE UPON YIELD AND GROWTH OF McINTOSH APPLE TREES

Tree No.	Girth in Inches Sept. 1927	Pounds Sodium Nitrate Applied			Yield in Bushels		Average Elongation of Terminal Twigs in Inches				Total Elongation of Lateral Shoots Per Terminal Twig in Inches	
		July 14 1926	April 30 1927	May 2 1928	1927	1928	1925	1926	1927	1928	1927	1928
1	30.0	—	10	—	11.0	14.0	4.5	3.8	8.5	11.5	15.0	17.9
2	26.5	5	10	10	14.0	12.5	7.0	6.0	11.2	11.2	23.3	9.5
4	28.0	5	10	10	18.0	13.5	8.5	3.5	9.7	7.9	14.8	19.2
5	28.25	—	10	—	21.0	10.0	5.0	4.0	9.5	6.7	24.0	9.7
6	27.0	5	10	10	18.0	10.0	4.5	3.8	11.5	9.6	13.3	17.9
7	28.5	—	—	10	9.0	14.25	6.3	4.5	6.0	7.4	7.3	9.2
8	27.5	5	—	10	12.5	13.5	7.0	4.0	8.0	11.0	10.8	17.7
9	21.0	—	—	—	1.0	2.5	5.3	3.3	4.7	4.5	1.3	1.1
10	23.25	10	—	—	15.0	7.0	3.8	3.5	9.2	7.5	22.3	14.9
11	24.0	—	—	—	5.0	5.5	4.0	3.8	4.5	5.7	2.3	6.5
12	24.75	10	—	—	16.5	6.0	5.0	3.3	9.2	8.0	6.5	13.6
13	26.0	—	—	—	5.0	5.0	6.2	4.5	4.0	4.3	3.5	6.4
14	26.0	5	10	—	19.0	8.25	5.3	3.8	10.0	7.7	13.3	15.9
15	22.0	—	—	—	1.0	0.25	2.8	2.5	3.8	3.6	0.2	1.3
16	24.5	10	10	—	13.5	5.5	5.0	3.0	9.0	6.9	20.3	13.2
17	24.25	—	—	10	3.0	4.5	4.8	3.3	3.8	4.1	0.5	0.4
18	25.5	5	10	10	12.0	7.5	5.0	3.8	11.5	7.2	12.0	13.0
19	23.0	—	—	10	2.0	6.5	5.3	4.5	6.0	9.7	0.0	8.6
20	26.75	5	10	10	14.0	9.0	7.3	4.3	9.7	7.7	10.0	15.6
*21	24.75	—	—	—	8.0	4.5	5.3	3.5	5.2	5.2	4.8	4.4
22	26.5	5	10	10	18.0	9.0	3.5	2.5	7.2	8.1	22.3	14.7
*23	16.75	—	—	—	1.0	0.5	6.0	3.8	4.0	7.1	2.5	3.9
24	26.0	5	10	10	19.0	6.0	8.3	4.5	10.0	7.6	9.8	12.4

*There is evidence that tree 21 inadvertently had access to a small amount of nitrate prior to the 1927 growing season. However, it is included in the averages for the checks to offset the disadvantage in size of check tree 23, which is evidently a replant.

The 11 trees with highest yields in 1927, had all received sodium nitrate, and all showed a decrease in 1928. The 7 trees that received sodium nitrate in 1926, 1927, and 1928, bore only about 3/5 as much fruit in 1928 as in 1927, there being a decrease in every case. On the other hand, the 6 trees that were untreated checks throughout the experiment, bore about 9/10 as much fruit in 1928 as in 1927; 3 of the checks decreased, 1 remained the same, and 2 increased. In this special case, starting with starved trees, the initial effect of sodium nitrate seems to have been to increase the fluctuation in yield from 1927 to 1928 by causing an extremely heavy crop in 1927. The exceptionally favorable weather for pollination that year may have been a contributing factor.

A study of Table I will reveal that both the immediate and the residual effects of each treatment upon growth, have been similar to the effect upon yield. Throughout the experiments, the percentage of increase due to sodium nitrate has been least in terminal growth, next in yield, and greatest in lateral growth. For example, trees 8, 10, and 12, in 1927, as a result of the second-year effect of the midsummer 1926 application, produced about 1¾ times as much terminal growth, 3 times as much fruit, and 3¾ times as much lateral growth as untreated checks 7, 9, and 11.

General Observations

Prior to the initial application of sodium nitrate in midsummer 1926, all the trees had pale foliage. Three weeks after application, the foliage color of each of the twelve nitrated trees, which were the even-numbered trees throughout the row, was distinctly darker that that of the adjacent checks. Five weeks after application, the nitrated trees stood out in bold relief from as great a distance as they were visible. The fruits on trees that received the midsummer application were perceptibly less highly colored at harvest time than those on check trees, but not enough so, to reduce their commercial value. No records were taken as to the size of the fruits in 1926. Terminal elongation had ceased at the date of the application and was not renewed as a result of the treatment.

In 1927 all trees bloomed heavily whether they had received sodium nitrate the preceding summer or not. In 1928 the percentage of spurs blooming appeared to be smaller on the trees that had borne extremely heavy crops in 1927 than on the others, but no whole tree or even large branch was without numerous blossoms. In 1927, weather was very favorable for pollination; in 1928, less favorable. Increases in yield resulting from applications of sodium nitrate were due to increases both in number and size of fruits. The color of the fruits varied inversely with the luxuriance of the foliage, the fruits of the check trees being of a solid, dark red. In 1928 the fruit commenced to drop from the untreated checks a week earlier than from the treated trees. This was true in adjacent blocks of Wealthy and Fameuse as well as in the McIntosh row. One tendency of these heavy applications of sodium nitrate has been to make the trees somewhat bushy by forcing a large number of spurs into growth as lateral shoots. It must not be concluded that all varieties would respond in the same way.

Discussion

So far as the author is aware, attempts have not previously been made to measure the magnitude and duration of the residual effects of sodium nitrate upon apple trees in the orchard, although random observations have been made. There is nothing in these experiments to show whether the residual effects have been due more largely to hold-over of nitrogen in the tissues of the tree or in the soil. That trees are capable of storing a nitrogen reserve is rather generally accepted. Some experiments with young trees in culture by Roberts (1) showed that "under conditions of low nitrogen nutrition the type and appearance of foliage and growth are more influenced by the composition of the wood as a result of previous treatment than by the current seasonal condition." However, in the present experiments there was some hold-over in the soil, for annual weeds, notably ragweed, grew more vigorously in 1927 under trees that received nitrate only in 1926, than under untreated checks.

It is suggested that one reason why the first year effect of sodium nitrate (on trees 17 and 19) in 1928 was less marked than the first year effect on trees fertilized in 1927, was the high watertable that prevailed through most of the spring and early summer of 1928. This saturated condition of the soil may have interfered with the absorption of nitrogen by the roots. It is unlikely that the crop of 1927 limited the response of these particular trees, for their 1927 crop was light. Nor was it a lack of pollination, for the response in growth, as well as in yield, was small. Some nearby trees of the variety Fameuse that received sodium nitrate June 15, 1927, made a vigorous response in yield and growth in 1928, suggesting that all trees would have responded well in 1928 if the nitrogen had been absorbed.

This is an instance in which striking increases in yield and growth have been obtained in a soil very low in humus content, merely by the application of an inorganic fertilizer.

Plans for the future include attempts to measure the limit of duration of the residual effects of sodium nitrate on yield and growth experiments with other varieties, with other sources of nitrogen, and with other fertilizer elements.

Summary

Evidence has been presented to show (1) that sodium nitrate increased the two-year yield and growth of McIntosh apple trees over 200 per cent in a New York orchard that is cultivated except for a small clump of grass around the trunk of each tree, (2) that the effects of the treatment were considerable not only the year in which sodium nitrate was applied but also during the second and third years, (3) that the response to nitrate was greatest in lateral growth, next in yield, and least in terminal growth, and (4) that in this particular case starting with starved trees the initial effect of sodium nitrate was to increase the fluctuation in yield from 1927 to 1928.

Literature Cited

1. Roberts, R. H. Nitrogen reserve in apple trees. Proc. Am. Soc. Hort. Sci., 18:143–145. 1921.

A Preliminary Report on Peach Fertilizer Experiments in Maryland

By E. C. Auchter and A. Lee Schrader, *University of Maryland, College Park, Maryland.*

Experiments in peach orchard fertilization were started by the University of Maryland in the spring of 1922. One experiment was located in the central part of the state on a rather heavy red clay loam soil at Mt. Airy and two in the southern part of the Eastern Shore at Salisbury and Berlin. Since the West Virginia and Delaware (3) experiments adjoining Maryland had clearly shown the value of a quickly available nitrogen carrier, it seemed unnecessary to lay out a large number of plots and conduct extensive experiments. Consequently, the tests were arranged as combined demonstrational experimental plots. The plots in the Mt. Airy and Salisbury orchards consisted of 10 trees each, while 20 trees per plot were used in the Berlin test. In most cases, the rows adjoined. The ground was practically level in each orchard and the soil appeared very uniform in all plots.

Berlin Experiment

Table I presents a summary of the results secured in the Berlin experiments. Nitrogen, either alone or in combination with phosphorus, caused a significant increase in trunk circumference, terminal

TABLE I—Effect of Fertilizer Treatments on Trunk Growth, Terminal Growth and Yield of Carman Peach Trees, Ten Years Old in 1922. Sandy Loam Soil (Berlin, Maryland)

Treatment	Total Increase in Trunk Cir. per Tree in Inches 1922–1928	2-Year Average Length Terminal Growth per Tree in Inches 1927–1928	Total Yield per Tree in Bushels 1923–24–26–27–1928	Total Yield in Bushels per Tree in 1927+1928
Nitrate of Soda	8.91	18.8	17.93	5.27
Nitrate+Lime	8.84	17.9	17.97	5.35
Ammonium Sulphate	8.74	19.7	18.35	5.70
Ammonium Sulphate+Lime	8.45	17.3	17.79	5.81
N+P	8.29	18.2	18.96	5.67
P	5.57	7.3	11.13	1.57
K	5.68	7.4	13.79	1.92
P+K	5.60	7.1	12.62	1.65
Check	6.55	11.4	14.39	3.72

Fertilizer Applications in Pounds Per Tree

Materials	1922	1923	1924	1925	1926	1927	1928
Nitrate of Soda	1.50	1.50	2.00	3.00	4.00	5.00	5.00
Ammonium Sulph'te	1.12	1.12	1.50	2.25	3.00	3.75	3.75
Lime	10.00	10.00	10.00	0.00	0.00	0.00	0.00
Acid Phosphate	2.50	2.50	3.00	5.00	5.00	4.00	5.00
Muriate of Potash	1.50	1.50	2.00	3.00	3.00	3.00	3.00

growth, and yield per tree during the 5-year period. (Since frost destroyed most of the crop of 1925, yields for this year are not included.) Neither phosphorus nor potassium when used alone or in combination with one another caused an increase over the check. In fact, a slight decrease occurred in this orchard when these elements were used alone, as found by Alderman in West Virginia, but this may be due to a slight cross feeding of the check plot, which was located between two nitrogen plots. The difference in response secured from nitrogen in comparison to that secured from phosphorus or potassium was emphasized during the last two years of the experiments, as shown in the last column of the table. Considering the average for the five years, neither carrier of nitrogen seemed superior to the other as regards total growth and yield. The time of most rapid growth and the coloring of fruit were somewhat different in the two plots, however, and the first year's results secured from these two carriers were quite different. These are presented in Table IV, and are discussed in connection with it.

Salisbury Experiment

In Table II are presented the results secured at the Salisbury orchard. Here again, nitrogen, either alone or in combination, caused an increase in trunk circumference, terminal growth, and yield of fruit as compared to the other fertilizers and to the check. As in the Berlin results, phosphorus and potassium either alone or in

TABLE II—Effect of Fertilizer Treatments on Trunk Growth, Terminal Growth, and Yield of Belle of Georgia Peach Trees, Six Years Old in 1922. Sandy Loam Soil (Salisbury, Maryland)

Treatment	Average Increase in Trunk Cir. in Inches 1922 to 1927	5-Year Average Length Terminal Growth in Inches 1923–1927	Total Yield per Tree in Bushels 1923–24–26–27
Nitrate of Soda	8.73	18.48	16.60±0.555
Nitrate+Lime	9.40	18.88	17.17±0.519
Ammonium Sulphate	9.60	18.32	18.63±0.651
Ammonium Sulphate+Lime	9.02	18.36	17.14±0.578
N+P+K	8.92	19.16	14.95±0.303
N+P	10.25	17.36	18.32±0.444
P	6.88	12.36	12.03±0.337
K	7.12	12.72	12.83±0.701
P+K	6.57	12.32	14.46±2.14
Check	7.70	15.00	13.12±0.357

Applications in Pounds per Tree

Materials	1922	1923	1924	1925	1926	1927	1928
Nitrate of Soda	1.50	1.50	2.00	3.00	4.00	5.00	5.00
Amm'nium Sulph'te	1.12	1.12	1.50	2.25	3.00	3.75	3.75
Lime	5.00	5.00	10.00	0.00	0.00	0.00	0.00
Acid Phosphate	2.50	2.50	3.00	5.00	5.00	5.00	6.00
Muriate of Potash	1.25	1.50	2.00	3.00	3.00	3.00	3.00

combination did not appear to have any beneficial effects. In this orchard also, either nitrogen carrier seemed to be equally valuable when the results of *total* growth and yield during the five years were

averaged. The time of most rapid growth and the coloring of fruit in the two cases are discussed further on. As in the Berlin orchard, lime, in addition to the different nitrogen carriers had no effect in this orchard. The comparative effects of these two carriers during the first year are given in Table IV. The check plots in this orchard as well as in the Berlin orchard were located between two nitrogen plots and a slight amount of cross feeding has been noted especially in the last two years. This no doubt explains why they appear somewhat better than the phosphorus and potassium rows. Unfertilized rows in the orchard adjoining these experiments were from 10 to 15 per cent poorer in growth and yield than the checks.

Mt. Airy Experiment

Results secured in the Mt. Airy orchard are shown in Table III. In this orchard, phosphorus and potassium were not applied singly but either in combination with nitrogen or with each other and nitrogen, making a complete fertilizer. In this experiment the plot receiving the normal amount of nitrogen as nitrate of soda, has been used as the check. It will be noted that the addition of lime to the nitrate plot apparently did not affect growth or production. Where double amounts of nitrate of soda were used per tree, there could occasionally be noted a slight toxic effect during the last three seasons, and the trees did not grow quite as well as where the normal amounts were used. This can be noted in the table where the figures for trunk increase and terminal growth are recorded. Yields from these trees have been very satisfactory, however, and have equalled those from the other nitrogen plots.

TABLE III—Effect of Fertilizer Treatments on Trunk Growth, Terminal Growth and Yield of Elberta Peach Trees, Planted in 1922, Heavy Red Clay Loam (Mt. Airy, Maryland)

Treatment	Total Increase per Tree in Trunk Cir. in Inches 1922 to 1927	3-Year Average Length Terminal Growth in Inches 1925–26–27	Total Yield per Tree (Bushels) 1927–1928
Nitrate—single	14.72	17.6	7.28±0.370
Nitrate+Lime	14.35	17.0	7.44±0.704
Nitrate—Double Amts.	12.62	14.2	6.86±0.287
Ammonium Sulphate—single	13.38	17.3	6.09±0.299
Ammonium Sulphate+Lime	10.16	14.1	2.04±0.202
Ammonium Sulphate—double	13.31	16.2	6.07±0.442
N+P+K	15.19	17.3	12.14±0.441
N+P	14.51	18.3	7.03±0.285
N+K	14.36	16.6	9.44±0.398

Applications in Pounds per Tree

Materials	1922	1923	1924	1925	1926	1927	1928
Nitrate of Soda—single	0.25	0.25	0.50	1.50	4.00	5.00	5.00
Ammonium sulph'te	0.25	0.25	0.375	1.125	3.00	3.75	3.75
Lime	2.00	2.00	0.00	0.00	0.00	0.00	0.00
Acid Phosphate	0.50	0.50	0.75	1.50	4.00	4.00	4.00
Muriate of Potash	0.125	0.25	0.50	1.00	2.00	2.50	3.00

growth, and yield per tree during the 5-year period. (Since frost destroyed most of the crop of 1925, yields for this year are not included.) Neither phosphorus nor potassium when used alone or in combination with one another caused an increase over the check. In fact, a slight decrease occurred in this orchard when these elements were used alone, as found by Alderman in West Virginia, but this may be due to a slight cross feeding of the check plot, which was located between two nitrogen plots. The difference in response secured from nitrogen in comparison to that secured from phosphorus or potassium was emphasized during the last two years of the experiments, as shown in the last column of the table. Considering the average for the five years, neither carrier of nitrogen seemed superior to the other as regards total growth and yield. The time of most rapid growth and the coloring of fruit were somewhat different in the two plots, however, and the first year's results secured from these two carriers were quite different. These are presented in Table IV, and are discussed in connection with it.

Salisbury Experiment

In Table II are presented the results secured at the Salisbury orchard. Here again, nitrogen, either alone or in combination, caused an increase in trunk circumference, terminal growth, and yield of fruit as compared to the other fertilizers and to the check. As in the Berlin results, phosphorus and potassium either alone or in

TABLE II—Effect of Fertilizer Treatments on Trunk Growth, Terminal Growth, and Yield of Belle of Georgia Peach Trees, Six Years Old in 1922. Sandy Loam Soil (Salisbury, Maryland)

Treatment	Average Increase in Trunk Cir. in Inches 1922 to 1927	5-Year Average Length Terminal Growth in Inches 1923–1927	Total Yield per Tree in Bushels 1923–24–26–27
Nitrate of Soda	8.73	18.48	16.60±0.555
Nitrate+Lime	9.40	18.88	17.17±0.519
Ammonium Sulphate	9.60	18.32	18.63±0.651
Ammonium Sulphate+ Lime	9.02	18.36	17.14±0.578
N+P+K	8.92	19.16	14.95±0.303
N+P	10.25	17.36	18.32±0.444
P	6.88	12.36	12.03±0.337
K	7.12	12.72	12.83±0.701
P+K	6.57	12.32	14.46±2.14
Check	7.70	15.00	13.12±0.357

Applications in Pounds per Tree

Materials	1922	1923	1924	1925	1926	1927	1928
Nitrate of Soda	1.50	1.50	2.00	3.00	4.00	5.00	5.00
Amm'nium Sulph'te	1.12	1.12	1.50	2.25	3.00	3.75	3.75
Lime	5.00	5.00	10.00	0.00	0.00	0.00	0.00
Acid Phosphate	2.50	2.50	3.00	5.00	5.00	5.00	6.00
Muriate of Potash	1.25	1.50	2.00	3.00	3.00	3.00	3.00

combination did not appear to have any beneficial effects. In this orchard also, either nitrogen carrier seemed to be equally valuable when the results of *total* growth and yield during the five years were

TABLE IV—FIRST YEAR'S GROWTH AND FRUITING OF PEACH TREES FOLLOWING APPLICATIONS OF NITRATE OF SODA AND AMMONIUM SULPHATE

Treatment	Berlin Orchard Carman Variety 10 Years Old in 1922		Salisbury Orchard Belle of Georgia Variety 6 Years Old in 1922	
	Increase in Trunk Cir. in Inches per Tree	Yield in Bushels per Tree Following One Year's Growth	Increase in Trunk Cir. in Inches per Tree	Yield in Bushels per Tree Following One Year's Growth
	Fall of 1922	1923	Fall of 1922	1923
Nitrate of Soda......	1.27±0.121	3.32±0.231	2.00±0.150	6.09±0.298
Ammonium Sulphate...	0.86±0.055	1.31±0.104	1.66±0.108	4.28±0.264
Nitrate+ Lime......	1.52±0.122	2.67±0.230	2.26±0.100	6.68±0.271
Ammonium Sulphate+ Lime......	0.99±0.096	1.41±0.158	1.93±0.098	4.53±0.336
Check.......	0.79±0.130	1.21±0.198	1.70±0.092	4.72±0.298

In both of these orchards which were low to medium in vigor at the start of the experiments, nitrate of soda during the first year resulted in a greater tree growth as measured by trunk circumference than did ammonium sulphate. As a result of the greater growth, more bearing wood and more fruit buds were formed and larger yields per tree were secured the following year. All of these differences were significant except the trunk measurements in the Salisbury orchard.

Apparently, the nitrate of soda was available earlier in the spring than ammonium sulphate and greater growth and more fruit buds resulted during the first year. These results with peaches were similar to those with apples, reported by the authors in previous meetings of this society (7 and 8). After the first year, however, when the trees apparently accumulated a reserve of nitrogen, no difference in total growth or yield could be noted between the two carriers as shown in Tables I and II. Probably these differences would not be noted even during the first year if the trees were fairly vigorous at the start. It was noted, however, that those trees fertilized with ammonium sulphate were making more vigorous growth in midsummer than were the trees fertilized with nitrate of soda. The fruit also seemed to be slightly later in ripening and coloring than that from the nitrated trees.

EFFECT OF NITROGEN ON COLOR AND MATURITY OF FRUIT

Trees receiving nitrogen produced more wood growth and more and larger leaves than the no-nitrogen trees. As a result, fruit from the nitrogen trees matured from three days to a week later, depending upon the season, than that from the check or phosphorus and potassium plots. Thus the largest pickings of fruit from the no-nitrogen plots occurred a few days ahead of the largest pickings from the nitrogen plots. The fruit on the nitrogen plots, while not quite so high in color as that from the no-nitrogen plots, became satisfactory in color if left on the trees until of equal maturity with that of the

no-nitrogen plots at picking time. Storage and shipping experiments are now being conducted with fruits from the different plots.

Time of Application

Additional plots at Salisbury were conducted to study the effect upon growth and yield of applying nitrate of soda at different times of the year. Accordingly, plots were fertilized each year at different times for six years. One plot received its nitrogen in the dormant stage or just as the buds were swelling, one at petal fall, one after the June drop, one July 1st, one August 1st, and one September 1st. Although all plots did fairly well, those receiving their application in the dormant season, made a little better growth and produced about 15 per cent more fruit than the others. The petal fall application was nearly as good but the later applications did not produce quite as desirable results.

Literature Cited

1. Alderman, W. H. The fertilization of peach orchards. W. Va. Agr. Exp. Sta. Bul. 150. 1915.
2. Crane, H. L. Experiments in fertilizing peach trees. W. Va. Agr. Exp. Sta. Bul. 183. 1924.
3. McCue, C. A. A fertilizer experiment with peaches. Proc. Amer. Soc. Hort. Sci., 12:86. 1914.
4. Pickett, B. S. Response of a young peach orchard to certain cover crops and fertilizer treatments. Proc. Am. Soc. Hort. Sci., 17:193. 1920.
5. Ruth, W. A. The effect of certain potassium and nitrogen fertilizers on the shoot growth and flower formation of the peach. Proc. Am. Soc. Hort. Sci., 18:152. 1921.
6. Shaw, J. K. Some unusual results in fertilizing fruit plants. Proc. Amer. Soc. Hort. Sci., 21:281. 1924.
7. Schrader, A. L., and E. C. Auchter. The first year's effect of different fertilizers on bearing apple trees low in vigor. Proc. Amer. Soc. Hort. Sci. 22:150. 1925.
8. Schrader, A. L., and E. C. Auchter. The comparative effects of different nitrogen fertilizers on bearing apple trees low in vigor. Proc. Amer. Soc. Hort. Sci. 24:229. 1927.

The Third Report on the Illinois Thinning Investigations

By M. J. DORSEY and R. L. MCMUNN, *University of Illinois, Urbana, Illinois.*

IN the first thinning investigations in Illinois (1), a study was made of the relation of seed development to the time of thinning. The following season, 1927, (2), the investigations centered upon the length of time of effective thinning and the time of twig growth in relation to fruit enlargement. These results extended the time of effective thinning well toward the "final swell." In view of the findings of the first two seasons, it seemed advisable to continue the experiments another year in order to check the results further under practical orcharding conditions.

Accordingly, in 1928 a test was made of the effect of thinning at different times during that interval beginning with the end of the June drop and extending up to the beginning of the so called "final swell."* While this period is not sharply defined at either end, it may be considered as the mid-period of growth. The investigations were extended to include this period because the interval between the end of the June drop and the hardening of the stone is too short to meet many of the conditions of practical orcharding. Both early and late varieties were included in the experiments this year, as will be seen by referring to Table 2, in which they are arranged in the order of the first picking date.

The plots were distributed north and south in the Illinois peach district so that there would be more leeway in taking records at picking time. In spite of the fact that great care was taken to include uniform trees in the experiments, at harvest time considerable variation was found in yield between trees. Rather than attempt to repeat the plots in fewer orchards so that the influence of individual tree variation upon yield could be evaluated, it was considered advisable this year to include a wider range of conditions.

As in the preceding experiments, the fruits were thinned to a distance of six inches as nearly as possible. The first thinning in each of the experiments was made after the June drop, but before the stone had hardened at the tip. This is the interval usually recommended for thinning, and this year, in Elberta, was about ten days in length. It was found difficult to make the subsequent thinnings at regular intervals as was planned, on account of delays from unfavorable weather and the distance involved.

The detailed measurements of size increase in the fruits, which had been made in the previous studies, could not be continued with the 237 trees in the plots this year; consequently, the effect of thinning upon size of fruit was measured at picking time by running the fruit

*A number of individuals have helped with these experiments. Mr. J. S. Potter and Ralph Chaplin assisted in taking the records in the experiment at Olney and Mr. C. Edward Baker at Tunnel Hill. We wish especially to express our appreciation to the growers mentioned in Table II, whose cooperation with the Department of Horticulture made these experiments possible.

TABLE I—SHOWING THE MONTHLY PRECIPITATION AT THE NEAREST POINT FROM EACH EXPERIMENT WHERE RECORDS WERE KEPT

Orchard	Reporting Station	Distance From Orchard to Reporting Station	April		May		June		July		August	
			Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal
McBride, M. J. Villa Ridge	Cairo	10 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Endicott, R. D. Villa Ridge	Cairo	10 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Schoembs, E. O. Villa Ridge	Cairo	8 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Corzine, C. R. Dongola	Anna	8 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Cobb, O. C. and Waterbury, H. B. Anna	Anna	4 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Hardin, L. T. Anna	Anna	2 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Bates, D. I. & Son Centralia	Mt. Vernon	15 miles	3.16	—0.39	5.28	+1.28	10.85	+ 6.60	1.49	—1.69	+5.02	+1.56
Simpson, F. L. and Landenberger, R. Olney	Olney	6 miles	2.93	—0.71	2.79	—1.16	7.24	+ 3.36	3.40	+ .06	3.35	—0.25
Foote, L. S. Tunnel Hill	New Burnside	4 miles	7.13	+2.84	3.00	—1.21	16.15	+12.57	2.31	—1.27	2.96	—0.39

over a mechanical sizer. On account of the distance between orchards and the necessity of having a sizer available, one which could be easily transported was constructed especially for this work. This sizer, set to separate the fruits in lots varying by one-fourth of an inch, was used in all but four of the experiments. In those plots which could not be reached with the special sizer the fruit was run over whatever machine the orchardist had available at the time of picking.

The thinning plots were located in orchards that had been given good care. While the spray schedules varied in the different orchards, yet, for the most part, insects and diseases were under good control, with the exception of the Oriental Fruit Moth in the Endicott orchard. All of the orchards were cultivated until about the middle of July; after that date native grass was allowed to grow. Nitrate applications, varying from 2 to 5 pounds per tree, were made in all orchards. The trees had been trained to an open center and while the severity of pruning varied somewhat, the extremes in either direction were not encountered in these experiments.

During the growing season of 1928 in Illinois, there was considerable irregularity in precipitation. A monthly summary from April to August is presented in Table I.

It will be seen from the table that the rainfall in May and July was below normal, but that in June there was an exceptional surplus. The deficiency in July undoubtedly had some bearing upon the size of fruit in the varieties ripening in mid-season, because toward the end of the summer the enlargement of the fruit was much less than is usually expected.

The experimental results for this season may be summarized under three main headings: (1) The range in the time of effective thinning as measured by size of fruit; (2) the effect of thinning upon total yield; and (3) the influence of tree condition and time of picking upon size of fruit.

RANGE IN THE TIME OF EFFECTIVE THINNING

The results of the first two years clearly indicate the advantage of waiting to thin until after the June drop because the number of fruits to be pulled off at that time is about one-fourth to one-half less. This year when the thinning was done after the June drop the number of fruits removed per tree in the different thinnings was fairly constant as shown in Table II. Furthermore, fewer "clusters" were left in the later thinnings when the peaches were larger and reduced in number by the June drop.

The set was heavy on Red Bird as will be seen from the large number of fruits removed per tree. The yield of the first trees thinned was somewhat less than those thinned later. This difference was due, for the most part, to size of tree, since there was not a late drop and the spacing of the fruit was the same on all trees. In this experiment the influence of the last thinning on size of fruit, being 18 days before picking time, is less than the first one, 15 days earlier. This same tendency was pronounced in the New Jersey

TABLE I—Showing the Monthly Precipitation at the Nearest Point From Each Experiment Where Records Were Kept

Orchard	Reporting Station	Distance From Orchard to Reporting Station	April		May		June		July		August	
			Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal	Precipitation	Departure from Normal
McBride, M. J. Villa Ridge	Cairo	10 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Endicott, R. D. Villa Ridge	Cairo	10 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Schoembs, E. O. Villa Ridge	Cairo	8 miles	5.76	+2.04	1.75	—1.96	15.70	+11.87	1.43	—1.64	3.95	+0.93
Corzine, C. R. Dongola	Anna	8 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Cobb, O. C. and Waterbury, H. B. Anna	Anna	4 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Hardin, L. T. Anna	Anna	2 miles	6.10	+1.67	2.63	—1.83	18.21	+13.70	0.52	—3.26	4.64	+0.65
Bates, D. I. & Son Centralia	Mt. Vernon	15 miles	3.16	—0.39	5.28	+1.28	10.85	+ 6.60	1.49	—1.69	+5.02	+1.56
Simpson, F. L. and Landenberger, R. Olney	Olney	6 miles	2.93	—0.71	2.79	—1.16	7.24	+ 3.36	3.40	+ .06	3.35	—0.25
Foote, L. S. Tunnel Hill	New Burnside	4 miles	7.13	+2.84	3.00	—1.21	16.15	+12.57	2.31	—1.27	2.96	—0.39

Endicott, R. D. Villa Ridge	Elberta Vigorous	First	7	5	6/4	41	71	559	Aug. 14–28		2	74	196	71	343	—48	+56
		Second	7	5	6/24	61	51	756	Aug. 14–28		1	31	210	101	343	—48	+100
		Third	7	5	7/10	77	35	583	Aug. 14–28		2	43	150	84	279	—112	+23
		Check	7	5					Aug. 14–28		16	164	184	27	391		
											2″ down	2″ up					
Foote, L. S. Tunnel Hill	Elberta Vigorous	First	5	10	6/11	44	68	489	Aug. 18–21		7[3]	131			138	—36	— 5
		Second	5	10	6/27	60	52	301	Aug. 18–21		20	100			120	—54	—36
		Third	5	10	7/27	90	22	312	Aug. 18–21		20	108			128	—46	—27
		Check	5	10					Aug. 18–21		39	135			174		
Bates, D. I. and Son Centralia	Elberta Medium in Vigor	First	11	7	6/5	36	77	853	Aug. 21–29		12[3]	138	153		303	— 5	+18
		Second	11	7	6/21	52	61	618	Aug. 21–29		17	142	113		272	—36	—22
		Third	11	7	7/7	68	45	597	Aug. 21–29		10	100	136		246	—62	+ 1
		Check	11	5					Aug. 21–29		35	138	135		308		
												2¼″ down	2¼″–2¾″	2¾″ up			
Simpson, F. L. and Landenberger, R. Olney	Elberta Vigorous	First	11	10	6/7	38	77	226	Aug. 23–28			24[3]	155	32	211	—76	—30
		Second	11	12	6/26	57	58	202	Aug. 23–28			17	144	35	196	—91	—38
		Third	11	11	7/23	84	31	306	Aug. 23–28			90	174	21	285	— 2	—22
		Check	11	12					Aug. 23–28			70	191	26	287		

[1]For Elberta 2¼ inches up—other varieties 2″ up.
[2]Fifteen trees were included in this experiment at the start but there were only three trees of Elberta.
[3]Run over a commercial grader with these sizes only available.

experiments with Belle (3), and can be expected when thinning is done after the final swell has begun. The proportion of fruit, however, above two inches is greater in the trees thinned on either date than on the check, in which over three-fourths of the fruit was below that size.

In Alton and Slappey, two other early varieties, there was a single thinning 30 and 20 days, respectively, before harvest. The effect of late thinning in these two varieties is similar to that in those ripening later. While there is no range in the thinning dates to consider in these varieties, they are included in the table because of the effect of thinning upon yield.

In the two experiments with Belle, the influence of three different thinnings upon size was practically the same. In each experiment, the last thinning was done about a month before picking. The range from the first to the last thinning was 34 to 36 days. Under the conditions of the experiments with Belle, the value of thinning at different dates in mid-season has been about equal in increasing size in fruit.

Turning now to Elberta, a later ripening variety than any of the others, it will be seen that five experiments were completed. There were three thinnings in each orchard except in that of Cobb and Waterbury, where the first two thinnings were omitted. The first thinning was made from 36 to 44 days after bloom and the last one 22 to 45 days before picking. While there was some variation with this variety in the classes into which the fruit was graded, the influence of thinning upon size at the different dates was not markedly different.

On the whole, therefore, the results of this season's work confirm those of the previous investigations. While some tree conditions have not been included, nevertheless the experiments have been carried out under practical conditions and accordingly should be comparable to results from thinning when done by growers.

Effect of Thinning Upon Yield

The idea is quite prevalent among growers that the increase in size of fruit as a result of thinning will make up in bulk for the fruit removed. This may happen under special conditions, but has not in these experiments. In view of the extent of the industry in the country as a whole, the principal consideration is not total yield as such, but total yield above the accepted minimum size for the better commercial grades.

The data in Table II show without exception that thinning reduced the total yield. The reduction was not serious in most instances, but in view of this, the figures in the last column of Table II are of special interest. With the exception of two Elberta experiments, the yield was increased in the larger sizes as a result of thinning to about the same extent as the total yield was reduced. Viewed from this angle, the loss in total yield from thinning is not so serious, especially in view of the difference in price level of fruit of the larger sizes. If the total yield is decreased by thinning, but at the same

time the yield of marketable fruit is increased, it is evident that the larger yields from the check plots is made up of the smaller-sized fruits. This is the test of the effect of thinning and it is in this direction that profits can be expected, rather than from total yield.

Influence of Tree Condition and Picking Date

In these experiments there was considerable variation in the vigor of the trees, record of which is entered in the second column for each plot, in Table II. Moderately vigorous was regarded as midway between a slow-growing tree with a twig extension under six inches and one very vigorous with a terminal growth of 36 inches or more.

In general, it may be said from a study of the plots this year that the more vigorous trees produced the larger fruit. The two experiments with Belle illustrate this best because the fruit was sized in the same classes in each experiment. Where the trees were heavily pruned, there was a tendency for the fruit on the check plots to "size up" practically as well as on the thinned trees. This tendency was most pronounced in the Simpson-Landenberger orchard, where the small number of fruits removed in thinning show that pruning had gone far in limiting the total load of fruit. For the second season, thinning was ineffective in increasing size in this orchard. Under these conditions the smaller fruits come for the most part from "clusters" where the set was heavy.

In addition to vigor of growth, time of picking had some bearing upon these results. In some of the experiments the first and second pickings were made while the fruit was quite green and before there had been much growth in the final swell. This was especially true with Elberta in the last two experiments. By studying the range in the size of fruit in these experiments, it will be seen that while a goodly proportion of the fruit comes within the commercial sizes, nevertheless, as compared with Elberta in the Endicott orchard, where the fruit was picked for a special trade when "eating" ripe, there is considerable difference.

The growth studies of Blake (4) and those presented in the second report by Dorsey and McMunn (2) show how rapidly the peach grows as maturity is approached. This is also shown by determining the number of fruits in 50 pounds at different times or for different sizes. One week after "shuck fall" when the peach averages .53 of an inch through the suture there are about 15,000 fruits in 50 pounds. Before the June drop when the diameter averages .91 of an inch, it takes 3,700 fruits to weigh 50 pounds. When the stone has hardened, Elberta fruits average 1.41 inches through the suture and 960 weigh 50 pounds. Near the beginning of the final swell with a diameter of 1¾ to 2 inches, the number in 50 pounds is reduced to 340. From now on the number in 50 pounds decreases rapidly and if the larger sizes are to be reached with a full crop, conditions must be very favorable. In sizes ranging from 2¼ to 2½ inches, 190 or so weigh 50 pounds; between 2½ and 2¾ inches, the number is reduced to 150 in 50 pounds, while at 3 inches in diameter only 90 or so

are required. By actual measurement of the volume of J. H. Hale measuring 2½ and 3½ inches in diameter respectively, it was found that the latter was about 3 to 3¼ times greater in volume.

These figures serve to illustrate the problem involved in getting size in peaches. While in some of the experiments early picking counteracted to some extent the effect of thinning by removing the fruit too early in the final swell, at the same time it tended to help the check trees where the load was heaviest.

SUMMARY

1. The experiments of 1928 show that peach thinning is effective throughout the mid-period of growth, from the end of the June drop to the beginning of the "final swell." By placing these limits upon thinning, the large number of fruits eliminated naturally by the June drop are avoided and the operation is made more flexible because smaller and more experienced crews can be used, late drops avoided, and thinning can be better fitted into the different orchard operations. The earlier varieties and those with an exceptionally heavy set can be thinned first.

2. In these experiments, thinning has without exception reduced the total yield, but at the same time, has increased the proportion of the crop above the lower limits for the better commercial grades. Early picking does not take full advantage of the rapid growth of the peach before becoming "market" ripe. The grower can gain considerably by keeping these alternatives in mind. It may be advisable to pick a part of the crop early for distant shipments, and still let a portion of it remain on the tree longer, and to that extent increase the yield.

3. Tree condition was found to have a big influence upon "sizing up" fruit. The results from thinning may be disappointing when the trees lack vigor or are in need of pruning. On the other hand, it is possible so to limit the top by pruning, at least in Elberta, that under some conditions the trees will "size up" a relatively heavy set. In these cases, it seems advisable to restrict thinning for the most part to the breaking up of clusters.

LITERATRUE CITED

1. DORSEY, M. J., and MCMUNN, R. L. The development of the peach seed in relation to thinning. Proc. Am. Soc. Hort. Sci., 402–414. 1926.
2. DORSEY, M. J., and MCMUNN, R. L. Relation of the time of thinning peaches to the growth of fruit and tree Proc. Am. Soc. Hort. Sci., 221–228. 1927.
3. FARLEY, A. J. Factors that influence the effectiveness of thinning. Proc. Am. Soc. Hort. Sci., 145–151. 1923.
4. BLAKE, M. A. Growth of fruits of the peach. N. J. Agr. Exp. Sta. Ann. Rept. 40:82–88. 1919.

Size of Peaches as Affected by Time of Thinning
A Preliminary Report

By H. E. KNOWLTON and M. B. HOFFMAN, *West Virginia University, Morgantown, W. Va.*

TO the peach grower, thinning of fruit has become almost as important and profitable as pruning and spraying. This has come about through necessity because of increased competition in marketing and the premium paid for large, well-colored fruit.

While the literature abounds with information on the proper distance apart to thin peaches it is exceedingly meagre of experimental data on the proper time to thin. Seemingly, recommendations to growers on time of thinning have been based on theoretical considerations rather than on results of field tests. Dorsey and McMunn (1926 and 1927) should be commended for reopening this subject and insisting upon experimental verification for the practise of thinning after the June drop but before the pit hardens. The studies herein reported were undertaken because of the desire of growers that the recent work of Dorsey and McMunn be checked under West Virginia conditions—particularly the practical phases.

From the practical standpoint there are many advantages in late thinning. First, less fruit will be removed in late thinning because of the more or less constant dropping that occurs in the interim between the time that fruit is normally thinned and the time of the late thinning (3–4 weeks before ripening). Second, there is opportunity in the late thinning to remove blemished fruits—fruits injured by curculio, hail, limb rubs, etc. Third, if late thinning is as effective as earlier ones the grower can spread the operation over a longer period, performing it with the regular help without going to the necessity of hiring additional help which is usually inexperienced. Or on the other hand, he can postpone this rather expensive operation until the last week in July, hire more labor and finish in a few days. This would be an exceptionally good plan to follow in sections where partial or total loss of crop from hail storms in mid-summer is of fairly common occurrence.

The thinning tests were conducted in the Fulton and Myers orchards. The Fulton orchard is located at Cherry Run, Morgan County, on a red and yellow shale soil generally low in fertility. Trees are of the Elberta variety and about ten years old. The orchard was given clean cultivation until midsummer when a volunteer cover crop was allowed to grow up. Light applications (3 pounds) of nitrate of soda have been made each year. Trees were making moderate growth with foliage of a healthy green color under this cultural treatment. The Myers orchard of the American Fruit Growers, Inc., is located near Martinsburg, in Berkeley County, on limestone soil of good fertility. Trees are also of the Elberta variety and about four years old. The orchard has been given about the same cultural treatment as the Fulton orchard. Trees were probably in a more vigorous condition than those in the Fulton orchard since the soil is deeper and more fertile.

Since data were to be analyzed by Student's Method the plan of the tests was such as to facilitate this. In each orchard ten pairs of trees were carefully selected as to size of tree and of crop. The fruit on one tree of each pair was thinned on June 29 and 30 and the fruit on the other August 1, so that the fruits were about six inches apart —the spacing common to this section. Pits were beginning to harden at the time the first thinning was made. Trees were well loaded but not uniformly, some limbs having a light crop, others a heavy one. The season was extremely favorable as far as rainfall was concerned, there being neither a scarcity nor a surplus up to time of harvest. At maturity 60 peaches were picked from each tree, 15 from each quarter, in so far as possible. Measurement in millimeters of transverse diameter of each fruit was made with calipers. This method of taking data on thinning experiments is similar to the one used by Rollins (1927) with apples. Total yields also were taken.

TABLE I—Early Thinning vs. Late Thinning of Elberta Peaches
Average Diameter (cm.) Sixty Peaches from Each Tree of Each Pair (1928)
Comparison by Student's Method

Fulton Orchard				Myers Orchard			
Pair	Early Thinning	Late Thinning	d	Pair	Early Thinning	Late Thinning	d
1	5.3	5.8	—0.5	1	5.7	5.7	0.0
2	5.9	5.8	+0.1	2	5.6	5.6	0.0
3	6.1	5.3	+0.8	3	5.7	5.5	+0.2
4	5.9	5.7	+0.2	4	5.8	5.5	+0.3
5	5.8	6.1	—0.3	5	5.5	5.4	+0.1
6	5.8	6.1	—0.3	6	5.7	5.7	0.0
7	5.9	6.0	—0.1	7	5.8	5.6	+0.2
8	5.8	5.4	+0.4	8	5.6	5.8	—0.2
9	5.8	6.2	—0.4	9	5.9	5.7	+0.2
10	6.1	5.7	+0.4	10	5.9	5.8	+0.1

M = +0.3, σ+0.40, Z = 0.007
No odds

M = +0.9, σ = 0.137, Z = 0.65
Odds of 22.5 to 1 in favor of Early Thinning.

Examination of data in Table I shows no significant difference in favor of either thinning. The indication of greater size of fruit on the early thinned trees in the Myers orchard cannot be attributed to the thinning but to spray injury which began to be evident at about the time the late thinning was performed. This injury caused a heavy drop of foliage and was more severe on the late thinned trees. It also affected the yield, for when the individual tree yields in this orchard were compared by Student's Method they showed odds of 132 to 1 in favor of early thinning. Size of fruit was also affected, the dwarfing of size being proportional to the severity of injury.

The total yield from the two plots in the Fulton orchard was also divided into two groups, those under 2 inches and those above. These figures are summarized in Table II. It will be observed that the total yield from the late thinned trees was slightly greater. This is probably due to differences in tree size in certain pairs and not attributable to the thinning. In fact the small difference in yield indicates good selection and pairing of trees.

TABLE II—YIELD AND SIZE OF ELBERTA PEACHES ON EARLY AND LATE THINNED PLOTS. FULTON ORCHARD. (1928)

Time of Picking	Total Yield Ten Trees Thinned June 29 (Bushels)			Total Yield Ten Trees Thinned August 1 (Bushels)		
	Less Than 2″	More Than 2″	Total	Less Than 2″	More Than 2″	Total
August 29........	0.5	13.5	14.0	1.0	14.0	15.0
September 1......	0.12	10.87	11.0	0.25	11.25	11.5
Total Yield.......	0.17	24.37	25.0	1.25	25.25	26.5

The slightly larger amount of peaches under 2 inches from late thinned trees is believed due to the fact that they were greener when picked and consequently slightly smaller. It should be mentioned that the fruit for Table I was picked by the authors while the rest was picked by regular pickers. This immaturity was clearly shown when the soft ones were sorted from each lot. Out of 14 bushels picked from the early thinned trees at the first picking, 1½ bushels were soft while only ⅓ bushel of soft fruits was found in the 15 bushels picked from the late thinned trees. This difference in maturity may have been caused by the thinning and from physiological considerations might be expected. It was not evident in the Myers orchard, but may have been masked by the injury caused by spraying. It will have to be checked up in subsequent experiments.

It is believed that the results obtained in these two experiments, together with those obtained by Dorsey and McMunn from two years' work in Illinois, are sufficient evidence for a tentative recommendation to growers that peach thinning can be effectively done until 3 or 4 weeks before harvest. It is planned, however, to continue these experiments for several years to get evidence for more definite recommendations.

LITERATURE CITED

1. DORSEY, M. J., and MCMUNN, R. L. The development of the peach seed in relation to thinning. Proc. Am. Soc. Hort. Sci., 402–414. 1926.
2. ————. The relation of the time of thinning peaches to the growth of fruit and tree. Proc. Am. Soc. Hort. Sci., 221–228. 1927.
3. ROLLINS, H. A. A new method for use in apple thinning experiments. Proc. Am. Soc. Hort. Sci., 93–94. 1927.

Fruiting and Growth in the Lombard Plum: Some Effects of Thinning

By J. H. WARING, *University of Maine, Orono, Maine.*

THAT a tree does not in the same growing season, both make vigorous growth and produce a heavy crop has been observed from time to time, and more recently papers have appeared which lead us to consider that to limit a fruit crop by thinning results in greater tree vigor. This paper will add somewhat to the evidence supporting that view.

Chandler (1) has summarized the literature up to 1925 as to the effects of thinning upon the fruit and upon the tree, drawing upon the work of Auchter, of Pickering, of Gourley, of Kraybill, of Hooker and Bradford, and of himself for evidence that heavy fruiting checks tree growth in the same year, and the suggestion follows that thinning may be beneficial by diverting to the use of the tree, for growth, material that would naturally have been used for the maturing of excessive fruits. Numerous other horticulturists have mentioned the conservation of tree vigor as a beneficial effect of thinning.

Referring to the June drop as a natural method of thinning, Waugh (2) says. . ."At other times the thinning is the salvation of the trees. Many varieties of plums set much larger crops than the trees can carry, and unless the fruit is thinned in some way the results are disastrous." Crane (3) mentions exhaustion, a result of heavy cropping, as shortening the life of the apple tree in West Virginia.

Partridge (4), Waring (5), and Anthony and Waring (6) have found high correlation between tree growth and fruitfulness in the apple when performance over a period of several years is averaged; but Wiggin (7) has shown that growth and yield in the same year are not directly correlated. By correlating growth in each of seven years with yield in the same and in the following year, he found that with Ben Davis, an annual bearer, there is little correlation in the same year and none at all between growth in one and yield in the following year; and that with Baldwin and Golden Russett, alternate bearers, the ratios are all either slightly or significantly negative. Apparently when a tree was making its greatest growth it might be producing its lightest crop.

Roberts (8) found the greatest number of xylem cells in vegetative spurs of Wealthy apple, fewer in defruited spurs, and fewest in fruiting spurs. The several papers recently presented by Murneek, giving results of investigations with the tomato (9, 10), indicate the possession by the fruit of a most extraordinary power for absorbing the important plant constituents, and thus leading to a marked reduction, or even complete cessation, of vegetative development. These, and his observations as to similar conditions producing similar effects in the apple (11, 12), point to the probability that fruiting is an exhaustive process.

In the spring of 1925 an experiment was started in a block of Lombard plums at the Graham Horticultural Experiment Station, Grand

Rapids, Mich. The trees had been set in 1920, bore their first fruit in 1924, and set a very scattered crop in 1925. Fifty-six trees in six contiguous rows were left unthinned. Forty-eight trees in the following six rows were thinned to one inch or more between fruits. In 1926 the natural set was uniformly heavy, and the 48 trees previously thinned were again thinned (June 29 to July 3), but seven of them more severely. Counts indicated 2.3 fruits removed to 1 remaining, and 6.5 to 1, respectively, in the two degrees of thinning. An admixture of varieties limited the experiment to these 56 Lombards unthinned, 41 thinned moderately, and 7 thinned more severely. In 1927 there was a complete crop failure. In 1928 the set was heavy and no thinning was done.

Certain averages and comparisons based on the crop records are presented in Table I. It is seen that in 1924, before thinning was begun, the trees in the group later to be thinned moderately bore 60 per cent more than those to be left unthinned, but the seven trees to be severely thinned bore 55.2 per cent less. Apparently those to be thinned moderately had some natural advantage at that time.

TABLE I—Yields from Thinned and Unthinned Plum Trees

Crop Year	Unthinned in 1925 and 1926	Thinned Moderately in 1925 and 1926		Thinned Severely in 1926	
	Lbs. per Tree	Lbs. per Tree	Deviation From Unthinned (%)	Lbs. per Tree	Deviation From Unthinned (%)
1924	4.18±0.48	6.69±1.55	60.0	3.00± 0.84	—55.2
1925	32.25±2.02	18.72±1.31	—42.0	20.57± 4.88	—36.2
1926	132.95±3.38	67.87±1.81	—49.0	34.80± 2.69	—73.8
1928	224.35±6.40	281.46±8.01	25.5	328.86±16.27	46.6

In 1925 the crop was reduced by 42.0 and 36.2 per cent, respectively, on the trees of the two thinned groups. In 1926 the crop reduction was in direct proportion to the severity of thinning. In 1928, however, there was a large crop increase in the two thinned groups over the unthinned. This can be explained only as an effect of the thinning treatment given two years before.

By comparing weights of random samples of the fruit as picked, it was found that in 1925 and 1926 the weights of individual plums were proportional to the thinning, but in 1928 the trees formerly thinned produced the smaller fruits. These data are presented in Table II.

TABLE II—Average Numbers of Plums in One Pound as Influenced by Thinning

Crop Year	Unthinned in Any Year	Thinned Moderately in 1925 and 1926	Thinned Severely in 1926
1925	33.06±0.30	21.09±0.32	———
1926	38.93±0.43	22.62±0.31	20.43±0.35
1928	20.28±0.47	30.88±0.35	29.71±0.42

As many as fifteen props were required under some of the trees formerly thinned to prevent severe breakage by the crop of 1928, and the smallness of the plums presented a special marketing difficulty.

Trunk circumference measurements of the trees in this experiment, with comparisons, are presented in Table III.

TABLE III—TRUNK CIRCUMFEENCE MEASUREMENTS IN INCHES

Fall Season of Year	Unthinned in 1925 and 1926	Thinned Moderately in 1925 and 1926		Thinned Severely in 1926	
	Average Circumference	Average Circumference	Dev. from Unth.(%)	Average Circumference	Dev. from Unth. (%)
1920	1.58±0.021	1.62±0.027	2.5	1.54±0.072	—2.5
1924	9.29±0.094	9.43±0.110	1.5	9.80±0.236	5.5
1926	11.89±0.120	12.77±0.143	7.4	14.10±0.349	18.6
1927	13.63±0.133	14.72±0.151	8.0	16.36±0.375	20.0
	Percentage Increments in Circumference				
1920–4	488.0	482.1		536.3	
1924–6	28.1	35.4		43.9	
1926–7	14.6	15.3		16.0	
1924–7	46.7	56.1		66.9	

The trees in the group destined for moderate thinning had a slight advantage in size in 1920, and it may be that this fact and environmental difference bear a relation to the crop difference of 1924. Those to be thinned severely were smallest at first but outgrew the unthinned before any experimental difference was introduced. In 1926 and 1927 the thinned trees showed marked gains in growth over the unthinned. And when the increments in circumference within each treatment are expressed in percentage, it is seen that the unthinned trees made the slowest growth in the period from 1924 to 1926 and since, those thinned severely the most rapid, the differences being large.

Measurements of terminal growth were first made to determine whether its seasonal duration might be affected by thinning the fruit. In 1926 on the day that thinning was completed, July 3, 50 terminals were measured in each group. The same terminals were again measured July 26. The average length increments in this 23-days interval were 0.122 cm. on the unthinned, 1.520 cm. on the moderately thinned, and 2.590 cm. on the severely thinned. Thinning after the June drop and just about the time terminal buds were forming on these heavily-bearing trees had lengthened the period of growth; trees not thinned made practically no further terminal growth, and the most growth followed the more severe thinning.

Further measurements of terminal growth of 1926, in length and in diameter at first internode, were made in the spring of 1927. The record is presented in Table IV, and indicates the thinning to have made for growth both in length and in thickness.

In the summer of 1927 the differences in growth and luxuriance of foliage were so outstanding as to arouse questions on the part of visitors to the station. Someone asked whether nitrate of soda had been used on one side of the block and not on the other. It was found by trial that about 100 terminals and sub-terminals could be measured on a single tree, and so two trees in each treatment were thus measured July 29 and one tree in each on August 25. The comparison of these

TABLE IV—LENGTH AND DIAMETER GROWTH OF TERMINALS IN CENTIMETERS, 1926

Treatment	Length Growth			Diameter Growth		
	No.	Mean	Dev. from Uthn. (%)	No.	Mean	Dev. from Unth. (%)
Unthinned..	146	11.77±0.27	—	146	0.369±0.0028	—
Moderately thinned...	136	12.87±0.45	9.3	136	0.437±0.0049	18.4
Severely thinned...	105	12.03±0.31	2.2	104	0.455±0.0047	23.3

measurements presented in Table V, shows increased growths in the magnitude of 54.3 and 66.9 per cent, respectively, of terminals on the moderately- and severely-thinned trees July 29, and of 96.9 and 95.9 per cent August 25.

TABLE V—LENGTH GROWTH OF TERMINALS IN CENTIMETERS, 1927

Treatment	Measured on July 29			Measured on August 25		
	No.	Mean	Dev. from Unth. (%)	No.	Mean	Dev. from Unth. (%)
Unthinned .	200	20.55±0.41	—	100	17.56±0.42	—
Moderately thinned...	200	31.70±0.54	54.3	100	34.58±0.98	96.9
Severely thinned...	200	34.30±0.51	66.9	100	34.50±0.91	95.9

Observations recorded along with the measurements serve but to emphasize the differences here attributed to thinning. The experimenter consciously omitted many of the spur-like terminals on the trees that had not been thinned, and likewise some of the extremely long growths on the thinned, particularly on the severely thinned trees. He believes that the true averages would be more divergent than those recorded. Branches of unthinned trees were observed in 1927 to exhibit some of the effects characteristic of the Caldwell system of training by the tying down of branches. Terminal growth on a given branch might be small, but a shoot 50 cm. long arise from near its base. A spreading form charcaterized the unthinned trees, an upright form the thinned. A still further point of interest is that the infestation of aphids in 1927, so severe as to resist the control measures employed, was far worse and longer-continued on the more rank and succulent terminals of the trees formerly thinned. Had these been absent, there is no doubt that the terminals would have grown still more.

By the detailed measurement in late summer in 1927 of 13 branches from unthinned trees, 8 from moderately-thinned, and 7 from severely-thinned, it was found that length growth had been greater on the thinned in 1927, 1926, and 1925, but less in 1924, the year before the experiment was begun. Diameter growth of these branches was greater in the thinned on one-year, two-, three-, and four-year wood, the differences diminishing with the age of the wood.

No leaf-area measurements have been made, but in July, 1927, a number of weighings of leaves and of discs one cm. in diameter cut

from them made it apparent that gains in leaf weight accrue from thinning, and that only a fraction of these gains is due to increased thickness. It was concluded that spur leaves of thinned trees were somewhat larger and branch leaves to a more marked extent larger than those on unthinned trees.

The correlation between length and number of leaves was determined on 43 terminals cut at random from an unthinned tree to be 0.918 ± 0.016. After measuring these and additional terminals selected from the thinned trees, the following correlations were also found: between shoot length and internode number, $r = 0.925 \pm 0.012$; between internode length and internode number, $r = 0.776 \pm 0.032$. These results indicate that with increasing length growth the number of leaves also increases, and suggest the possibility that internode length may not increase at a rate to correspond to the increase in numbers of internodes.

Histological examination of spur and shoot samples taken in the summer and fall of 1926 gave strong evidence that the carrying of a full crop checked diameter growth by limiting the production of xylem tissue. In contrast with the unthinned, the xylem of thinned trees was greatly increased in late summer. This contrast may be seen in the lantern slides.

Literature Cited

1. Chandler, W. H. Fruit Growing. Houghton Mifflin Company. 1925.
2. Waugh, F. A. Vermont Agri. Exp. Sta. Rept. 206. 1899.
3. Crane, H. L. Observations on the factors influencing the length of life of apple trees in West Virginia. Proc. Amer. Soc. Hort. Sci., 18:207–11. 1921.
4. Partridge, N. L. Growth and yield of apple trees. Proc. Amer. Soc. Hort. Sci., 16:104–109. 1919.
5. Waring, J. H. The probable value of trunk circumference as an adjunct to fruit yield in interpreting apple orchard experiments. Proc. Amer. Soc. Hort. Sci., 17:179–185. 1920.
6. Anthony, R. D., and Waring, J. H. Methods of interpreting yield records in apple fertilization experiments. Penna. Agri. Exp. Sta. Bul. 173. 1922.
7. Wiggin, W. W. Alternate bearing habit of the apple. Master's thesis, University of Maine. 1924.
8. Roberts, R. H. Apple physiology. Wis. Agri. Exp. Sta. Res. Bul. 68. 1926.
9. Murneek, A. E. The effects of fruit on vegetative growth in plants. Proc. Amer. Soc. Hort. Sci., 21:274–276. 1924.
10. ————. Physiology of reproduction in horticultural plants—I. Mo. Agri. Exp. Sta. Res. Bul. 90. 1926.
11. ————. Is fruiting of the apple an exhaustive process? Proc. Amer. Soc. Hort. Sci., 22:196–200. 1925.
12. ————Fruit thinning in Missouri. Mo. Agri. Exp. Sta. Bul. 252. 1927.

Relation of Leaf Area to Size and Quality in Apples

By J. R. Magness, *State College of Washington, Pullman, Wash.*

THE average mature apple consists of about 85% water and 15% dry matter. Practically all the dry matter, consisting of carobhydrates, cellulose, hemi-celluloses, pectin materials, organic acids, etc., is material directly or indirectly synthesized in the leaves. The average apple weighing one-third pound contains about 22 to 24 grams of material formed directly as a result of photosynthetic activity of the leaves.

Haller and Magness (1) have reported the results of experiments conducted to determine the approximate leaf area required to grow Delicious, Grimes, and Ben Davis apples under Virginia conditions. During the past season, investigations of a similar nature have been carried on at Wenatchee, Washington, using Delicious, Winesap and Jonathan. Detailed tests were made on Delicious, with limited observations on Winesap and Jonathan.

The procedure was similar to that followed in the earlier work. On June 16 to 19, branches of Delicious were selected carrying 8 to 12 apples and containing a well developed leaf system. Leaves or apples were removed until the branches held one apple to 10, 20, 30, 50, or 75 leaves. Only normally developed leaves were allowed to remain on the branches, the small, wrinkled leaves which often develop on a fruiting spur being removed. The branches were than girdled, a ring of bark about one-third to one-half inch wide being removed.

The apples, when the work was started, were about five inches in circumference, and, calculated as a sphere, contained about two cubic inches of tissue. Circumference measurements were made at intervals of ten days to two weeks until the end of the season.

Three individual Delicious trees were used in the test, and a complete series of leaf areas was run on each individual tree. From 25 to 30 apples with each leaf area were measured through the season. At the end of the season the fruit was harvested and weighed, and after temporary storage, sugar determinations were made on duplicate samples of fruit from each leaf area.

A sufficient interval of time elapsed following harvest before samples for chemical analysis were made to allow complete change of starch to sugar. Consequently the analyses reported represent the maximum sugar content of the fruit.

The detailed results of the average measurements on the fruit with the different leaf areas are recorded in Table I. This shows the number of leaves per apple, total average leaf area per apple, the volume of the apple at the start of the test and when harvested, with the growth increment. These values are based on the circumference of the fruit, considering the fruit as a sphere. Though this is not strictly accurate the results are comparable, and show approximate differences in growth rate which can be expected.

from them made it apparent that gains in leaf weight accrue from thinning, and that only a fraction of these gains is due to increased thickness. It was concluded that spur leaves of thinned trees were somewhat larger and branch leaves to a more marked extent larger than those on unthinned trees.

The correlation between length and number of leaves was determined on 43 terminals cut at random from an unthinned tree to be 0.918 ± 0.016. After measuring these and additional terminals selected from the thinned trees, the following correlations were also found: between shoot length and internode number, $r = 0.925 \pm 0.012$; between internode length and internode number, $r = 0.776 \pm 0.032$. These results indicate that with increasing length growth the number of leaves also increases, and suggest the possibility that internode length may not increase at a rate to correspond to the increase in numbers of internodes.

Histological examination of spur and shoot samples taken in the summer and fall of 1926 gave strong evidence that the carrying of a full crop checked diameter growth by limiting the production of xylem tissue. In contrast with the unthinned, the xylem of thinned trees was greatly increased in late summer. This contrast may be seen in the lantern slides.

Literature Cited

1. Chandler, W. H. Fruit Growing. Houghton Mifflin Company. 1925.
2. Waugh, F. A. Vermont Agri. Exp. Sta. Rept. 206. 1899.
3. Crane, H. L. Observations on the factors influencing the length of life of apple trees in West Virginia. Proc. Amer. Soc. Hort. Sci., 18:207–11. 1921.
4. Partridge, N. L. Growth and yield of apple trees. Proc. Amer. Soc. Hort. Sci., 16:104–109. 1919.
5. Waring, J. H. The probable value of trunk circumference as an adjunct to fruit yield in interpreting apple orchard experiments. Proc. Amer. Soc. Hort. Sci., 17:179–185. 1920.
6. Anthony, R. D., and Waring, J. H. Methods of interpreting yield records in apple fertilization experiments. Penna. Agri. Exp. Sta. Bul. 173. 1922.
7. Wiggin, W. W. Alternate bearing habit of the apple. Master's thesis, University of Maine. 1924.
8. Roberts, R. H. Apple physiology. Wis. Agri. Exp. Sta. Res. Bul. 68. 1926.
9. Murneek, A. E. The effects of fruit on vegetative growth in plants. Proc. Amer. Soc. Hort. Sci., 21:274–276. 1924.
10. ————. Physiology of reproduction in horticultural plants—I. Mo. Agri. Exp. Sta. Res. Bul. 90. 1926.
11. ————. Is fruiting of the apple an exhaustive process? Proc. Amer. Soc. Hort. Sci., 22:196–200. 1925.
12. ————Fruit thinning in Missouri. Mo. Agri. Exp. Sta. Bul. 252. 1927.

TABLE I—RELATION OF LEAF AREA TO SIZE, GROWTH RATE, AND SUGAR CONTENT OF DELICIOUS APPLES. WENATCHEE, WASH., 1928

No. of Leaves per Apple	Leaf Area Sq. In.	Average Volume per Apple, Cu. In.		Growth Increment Cu. In.	Weight per Apple Grams	Per cent Sugar		
		At Start of Test	When Harvested			Reducing	Non-Reducing	Total
10	36.5	1.93	7.58	5.65	93	A—		10.06
						B— 9.19	0.45	9.64
20	73.0	1.94	9.97	8.03	134	A—10.23	1.01	11.24
						B— 8.96	2.12	11.08
30	109.5	1.97	12.56	10.59	170	A— 9.96	1.51	11.47
						B— 9.20	2.44	11.64
50	182.5	2.02	15.63	13.61	201	A—10.11	3.07	13.18
						B— 9.92	4.86	13.22
75	273.7	1.97	15.50	13.53	211	A—10.84	3.29	14.13
						B— 9.92	4.86	14.78

Under the conditions of this test 50 leaves per apple gave approximately as large fruit as did 75. With this leaf area, fruit which would pack approximately 88 per box was secured. With the smaller leaf areas there was a steady decrease both in size of fruit, and in the sugar content of the fruit. On the basis of apples per box, fruit grown with 10 leaves was smaller than 200 per box, fruit with 20 leaves would pack 150, fruit with 30 leaves 113, and with 50 leaves, 88 per box.

With the smaller leaf area per fruit, the leaves seemed to function somewhat more efficiently. Thus with 10 leaves, the fruit showed half the growth increment found with 30 leaves. It is true that the fruit with 30 leaves was higher in sugar content, and probably in dry weight, which was not determined. Also there was undoubtedly higher carbohydrate storage in the branches and buds carrying the greater leaf area. It seems highly probable, however, that there is actually greater efficiency in leaves with the reduced area per fruit, due to lack of accumulation of the products of synthesis.

There was an outstanding difference in the dessert quality of the apples from the different leaf areas. With less than 30 leaves per apple, the fruit was insipid in flavor, lacking in aroma, and almost inedible. With 30 leaves per fruit, the quality was fair, but not of the best for Delicious. With 50 and 75 leaves per fruit, typical prime Delicious quality developed.

The results emphasize those of the earlier work, to the effect that Delicious produced without an adequate leaf area is of very poor quality. Any grower who expects to make a permanent success of growing Delicious, should plan to thin the fruit to provide an adequate leaf area per fruit.

It is improbable that an average of 50 leaves per apple on unringed branches would result in fruit as large and as high in sugar as that here produced, since some of the synthesized materials would normally pass out of the immediate branch to the trunk and root system. Consequently, it is believed that it can be said with assurance that unless 40 to 50 leaves per fruit are available on Delicious, best market sizes and quality fruit cannot be produced.

It is interesting to compare the results obtained in this work with those reported earlier for Virginia. In the first place, the average leaf area on the Virginia Delicious was 2.5 square inches per leaf; here it was 3.65. Thirty leaves in Virginia, with an area of 75 square inches produced apples averaging 117.5 grams in weight. Twenty leaves in Wenatchee, with a total area of 73 square inches produced apples averaging 134 grams. The sugar content of the Virginia fruit was slightly higher. Seventy-five leaves in Virginia, total area 187 square inches produced fruit weighing 153 grams, and analyzing 15.95 sugar. Fifty leaves at Wenatchee, with an area of 182 square inches produced fruit weighing 201 grams, and testing 13.2 per cent total sugar. Notwithstanding the higher sugar content in the Virginia fruit, the total efficiency of the foliage at Wenatchee seems to be

Observations on Color Development in Apples

By J. R. MAGNESS, *State College of Washington, Pullman, Wash.*

ALTHOUGH there has been a great deal of work on the anthocyanin pigments of plants in general there has been only a limited amount of investigation on color development in apples. This is true notwithstanding the great economic importance of color development. While there is a certain relationship between all anthocyanin pigments there is considerable variation in the conditions under which these pigments are developed in different plant tissues.

There are two outstanding factors which appear to influence color development in apples. These are, first, the chemical composition of the fruit, and second, the light exposure. We have purposely mentioned the chemical composition of the fruit first in order to emphasize its importance. Most horticulturists have been inclined to think that light exposure is the all important factor in securing color in fruit. Though light exposure is essential to the development of anthocyanin pigment in apples, it is by no means the only factor involved.

The literature on plant pigments repeatedly emphasizes the relationship between anthocyanin development and the sugar and glucoside content of the tissues. This relationship seems to hold with apples. It is a common observation that apples will not take on any appreciable amount of red color until they reach a certain degree of maturity. We know that the sugar content of apples increases with the maturity. It is frequently stated that cold weather is necessary for apples to color, and probably cool weather does aid coloring but when fruit reaches a proper chemical composition it will color even in midsummer. Many of our summer varieties attain fairly high color. Thus the first determining factor in the coloring of apples is the chemical composition of the fruit rather than weather and light conditions.

During the past season Delicious and Winesap apples were grown at Wenatchee, Washington, with varying leaf areas per apple, ranging from 10 to 75 leaves per fruit. Under the conditions of this test the fruit with the largest number of leaves had the poorest light exposure, whereas fruit with 10 to 20 leaves had almost perfect light exposure. Table I shows the sugar content and the percentage of solid red color which developed on this fruit.

It is apparent from the data that the fruit with the best light exposure but with the lower sugar content failed to develop satisfactory color. Not only was the area of the color small, but the fruit was of dull, bronze red rather than the bright red which is typical of these varieties when well grown. This indicates that in apples as in other plant tissues there is a fairly close relationship between sugar content and anthocyanin development. It has been observed repeatedly that fruit on badly over-loaded branches with almost perfect light exposure often develops very poor color. Such fruit will not develop color under the most favorable light conditions. Jon-

athan apples from such a branch were removed from the branch and exposed directly to full sunlight for ten days with practically no increase in color development. These results indicate clearly the relationship between sugar content and associated chemical changes and color development in fruit.

TABLE I—RELATION OF LEAF AREA TO SUGAR CONTENT AND COLOR, DELICIOUS APPLES, WENATCHEE, WASH., 1928

No of Leaves	Sugar Content, Percent			Solid Red Color Average Percent of Surface
	Reducing	Non-Reducing	Total	
			10.06	
10	9.19	0.45	9.64	23
20	10.23	1.01	11.24	
	8.96	2.12	11.08	26
30	9.96	1.51	11.47	
	9.20	2.44	11.64	42
50	10.11	3.07	13.18	
	9.62	3.60	13.22	51
75	10.84	3.29	14.13	
	9.92	4.86	14.78	58

The statement is frequently made that nitrogen fertilizers reduce color through increasing shade as a result of denser foliage. Undoubtedly the denser foliage is partly responsible, but it is also probable, that under conditions of large nitrogen supply the sugar content of the twigs, buds, and fruit is lower than under conditions of nitrogen shortage. Consequently it seems highly probable that there is a direct effect of nitrogen on color as well as the indirect effect from shading.

One of the most controversial and widely debated subjects at the present time among western fruit growers is the question of whether or not potash and phosphorous fertilizers will increase color. On this point there is no definite information for western conditions. The use of large quantities of nitrogen tends to reduce color, but whether or not complete fertilizers will bring about better color development is highly questionable. If complete fertilizers have any tendency toward developing higher carbohydrate-nitrogen ratios in the plant than do corresponding amounts of nitrogen alone, it is quite probable that they should have some effect on color.

It has long been known that light is necessary to the development of red pigment of apples. Recent experiments conducted at the Washington Experiment Station indicate that that portion of the spectrum that is most effective for coloring apples is the ultra-violet. It has been found possible to color Jonathan apples by the use of dilute applications of ultra-violet light, applying the light for an hour each day for several days. Apples will stand only dilute exposure to ultra-violet light since strong exposures burn the fruit in a manner similar to sunburn.

The effect of ultra-violet light was further studied by detaching Delicious, Jonathan, and Rome Beauty apples and exposing them to direct sunlight and to sunlight that had passed through ordinary

window glass before reaching the fruit. Table II summarizes the comparative rate of color development under glass and under direct exposure to sunlight.

TABLE II—Color Development of Detached Apples Under Glass and in Direct Sunlight

Variety	Percentage of Solid Red Color					
	When Started		After 5 Days		After 12 Days	
	Under Glass	Full Sunlight	Under Glass	Full Sunlight	Under Glass	Full Sunlight
Jonathan........	6.8	8.6	10.5	37.7	44.0	96.0
Delicious.........	4.5	5.4	5.6	24.2	17.3	74.0
Rome Beauty.....	2.5	2.0	4.0	8.0	9.3	36.3

These data represent average estimates of color on 15 individual apples subjected to each treatment. The results indicate that color development under glass occurs only about one-fourth as fast as under direct exposure to sunlight. Thus it appears that the ultra-violet rays are the ones that are most effective in coloring apples.

The ultra-violet rays are easily absorbed as they pass through the air by moisture in the air, by dust, etc. They are present in highest concentrations at high elevations, while at low elevations they are absorbed out to a much greater degree. After a rain the air is clear of dust and if the weather is clear there will be a greater percentage of ultra-violet rays in the sunlight. These factors probably largely account for the fact that fruit grown at higher elevations tends to take on high color and also explains the tendency of fruit to color rapidly after a period of rainy weather. It has been impossible to detect any relation between moisture on the fruit surface and color development.

It seems probable also that part of the effect of cold nights on fruit coloring is through the association of cool nights with clear days when much ultra-violet light comes through. Cool nights, also, result in the yellowing and lightening of the foliage and the admission of more light to the fruit.

In experiments with detached fruit, moving the fruit into low temperatures at night as compared to holding at temperatures of 70 degrees, and exposing it to sunlight during the day has not resulted in increased amount of coloring. In fact, fruit held at 70 degrees at night colored distinctly more rapidly than did fruit held at 32 degrees at night.

Apples with sufficient sugar content will color readily following removal from the tree if exposed to favorable light conditions. Poorly colored Rome Beauty, Delicious, and Jonathan apples were picked on October 5th this year at Pullman, Washington, and the color development when exposed to full sunlight was noted. This fruit was from the shaded portions of the tree. During the first 24 hours no measurable increase in color occurred. Two or three days elapsed before the fruit began to color rapidly.

Some of these Delicious and Rome Beauty apples were placed in cold storage at 30 degrees for two weeks. Others were held at basement temperatures of 45 to 50 degrees for two weeks. This fruit was then exposed to sunlight. Instead of two days before color development became pronounced it was practically a full week before an appreciable increase in color development occurred. Delicious from cold storage, for instance, during the first week increased in color from 4 per cent to 11 per cent, and during the second week increased to 30 per cent. Rome apples from cold storage increased from 4 to 9 per cent during the first five days, and increased to 38 per cent during two weeks. The weather during the first week was very clear and would have been ideal for fruit coloring. Thus, after a period in darkness, considerable time elapsed following exposure to light before color formation began in the fruit.

It was also interesting to note that the fruit held in common storage which yellowed appreciably during the two weeks in storage, did not color as well following removal from storage as did the fruit held in cold storage. Thus Delicious from cold storage averaged 32 per cent color at the end of two weeks while similar fruit from basement storage averaged 20 per cent color. Rome apples from cold storage showed 38 per cent color while from common storage they showed 22 per cent color. The Delicious did not color nearly so rapidly following removal from storage as they did when exposed directly from the tree. Rome fruits, on the other hand, from cold storage colored as well following removal as did those exposed directly from the trees two weeks earlier. The Romes were relatively greener when picked than were the Delicious. These results suggest that there may be a definite stage of maturity during which apples color most satisfactorily, and that before the fruit reaches this stage or after it passes through this stage anthocyanin formation does not occur so readily.

There is real need for a study of the chromogen or preanthocyanin material in apples. Mrs. Wheldale Onslow states positively that this material is synthesized in the leaves, and moves into the colored tissues, where anthocyanin is formed. This hardly seems possible in the case of the apple, since fruit will color completely after detaching from the tree. Perhaps the chromogen is formed directly in the subepidermal region of the fruit, which during the growing season contains chlorophyll, and late in the season is generally associated with an abundant sugar supply. Further detailed biochemical and horticultural studies dealing with chromogen formation and anthocyanin development in apples should greatly increase our knowledge relative to color development in apples.

Some Climatic Influences in the Apple Industry of of Sweden*

By LEIF VERNER, *University of Idaho, Moscow, Idaho.*

THE unusual climatic conditions characteristic of the high latitudes embracing Norway and Sweden, together with the fact that many of our common cultivated fruits find their extreme northern limits in these two countries, makes the study of climatic influences in relation to the fruit species on the Scandinavian Peninsula of particular interest. The apple, pear, plum, and cherry, as well as most of the small fruits, are cultivated extensively and all reach their northern extremes in these countries.

The commercial apple industry of Sweden is confined to approximately the southern third of the country. Within this area the most extensive acreage of the fruit occurs in the coastwise regions, in the extreme south, and bordering the larger inland lakes. The climate of this entire area is of a maritime type, with comparatively mild winters, cool summers, and freedom from sudden temperature changes. Farther north, on the east coast along the Bay of Bothnia, the winter extremes are far below those of the south; but in the midsummer temperatures there is surprisingly little difference between north and south. Table I gives the mean temperature and precipitation records of selected stations in Sweden and the United States.

GROWING-SEASON CONDITIONS

From the standpoint of fruit growing the low summer temperature of Sweden constitutes probably the most significant feature of its climate. The average temperature so nearly approximates the minimum that will suffice for the normal growth and maturity of the trees and fruit that it allows but a scant margin of safety for unfavorable deviations from the normal weather means in other respects. A study of climatic conditions in relation to the conditions of trees and crops in Sweden covering a long period of years has shown that if a summer of lower than average temperatures follows a late spring, or is itself followed by an early fall, the resulting combination of a short and cool growing season is incapable of properly maturing either wood or fruit, and leaves the trees barren of vigorous fruit buds for the following year. If a cool summer is accompanied by rainfall much in excess of the average the fruit does not color and ripen well, fungus diseases become extremely hard to control, and again there is poor maturity of wood and little fruit-bud formation. In fact, it is evident that a combination of almost any second unfavorable factor with a cool summer results not only in damage to the current years' crop but in a material reduction of the crop for the ensuing year. In all such unfavorable seasons the low summer temperature seems to constitute the most important, single limiting factor; probably in part through its own deficiency and in part because it

*This paper is a brief resumé of a study made in Sweden in 1926–27 as a Fellow of the American-Scandinavian Foundation.

TABLE I—MEAN MONTHLY TEMPERATURES IN DEGREES FAHRENHEIT

Name	North Lat.	General Location	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Halmstad, Sweden	56° 40′	S. W. coast	30	30	33	42	51	59	62	61	55	46	38	32
Lund, Sweden	55° 42′	S. inland	30	30	33	41	50	58	62	60	55	46	38	32
Vastervik, Sweden	57° 46′	S. E. coast	28	28	31	39	48	57	62	60	54	45	37	30
Stockholm, Sweden	59° 21′	E. coast	26	25	29	38	48	57	62	60	53	43	35	28
Pitea, Sweden	65° 19′	N. E. coast	14	14	20	32	42	55	60	57	48	36	24	16
Philadelphia, Pa.	39° 57′		32	34	40	51	62	72	76	74	68	57	45	36
Madison, Wisconsin	43° 5′		16	19	30	46	58	68	72	70	62	50	34	23
MEAN MONTHLY PRECIPITATION IN INCHES														
Halmstad, Sweden	56° 40′	S. W. coast	1.9	1.6	1.7	1.4	1.9	2.3	3.5	4.1	2.8	2.6	2.2	2.2
Lund, Sweden	55° 42′	S. inland	1.6	1.4	1.5	1.4	1.6	2.1	2.8	2.8	2.2	2.3	2.0	1.8
Vastervik, Sweden	57° 46′	S. E. coast	1.2	1.1	1.2	1.2	1.5	1.8	2.5	2.6	1.8	1.9	1.9	1.5
Stockholm, Sweden	59° 21′	E. coast	1.0	0.9	1.1	1.1	1.4	1.6	2.4	2.6	1.7	2.0	1.5	1.3
Pitea, Sweden	65° 19′	N. E. coast	1.1	0.8	0.9	0.9	1.3	1.3	1.9	2.3	2.1	1.9	1.6	1.1
Philadelphia, Pa.	39° 57′		3.3	3.4	3.4	2.9	3.2	3.2	4.2	4.5	3.3	3.0	3.2	3.0
Madison, Wisconsin	43° 5′		1.7	1.6	2.2	2.4	3.5	4.2	4.1	3.1	3.2	2.5	1.8	1.7

renders the trees less tolerant of other adverse conditions. Similarly, low summer temperature has been the predominant factor in restricting the extension and limiting the success of fruit growing north of the commercial fruit region.

Of the several adverse conditions that may be associated with low growing-season temperatures, heavy precipitation has proved by far the most serious. Crop responses to the relationship of temperature and precipitation are so consistent that, other things being equal, the temperature-precipitation ratio of the growing-season can almost be taken as an index of crop conditions. Table II shows the mean temperatures and total precipitation from May to September inclusive, for selected years and stations, together with the resulting conditions of the crops. Much depends, of course, upon the distribution of temperature and rainfal throughout the season; but it is clear that in general temperatures somewhat higher and rainfall somewhat lower than the normal favors the production of a good crop, while under the reverse conditions the crop is likely to suffer.

TABLE II—Growing Season Temperature and Precipitation in Relation to Apple Crops
(Averages given are for 15 stations in the commercial apple sections.)

Year and Place	Mean Growing Season Temperature	Total Growing Season Precipitation	Condition of Crop and Trees
40 year average.......	56.6°	10.9 inches	
1921—average........	57.0°	9.3 "	very good
1922—average........	55.4°	11.9 "	poor
1922—Kalmar........	56.8°	8.1 "	very good
1923—average........	54.4°	13.6 "	poor
1923—Halmstad......	56.0°	16.1 "	very poor
1923—Vastervik......	55.2°	9.6 "	good

It is not the contention that this parallelism between the temperature-precipitation ratio and crop conditions is due entirely and directly to only the two factors expressed in the ratio. A favorable temperature-precipitation ratio—that is, high temperature and low rainfall—is normally accompanied by a relatively high percentage of sunshine, high light intensity and low humidity, each of which would have a favorable bearing on crop conditions. The temperature-precipitation ratio in itself, therefore, is not a direct and independent determinant of crop responses; but should serve as an arbitrary figure to express favorable or unfavorable interrelationships among a number of climatic factors, each of which exerts some influence and each of which varies directly with varying intensities of either one or the other of the two elements making up the ratio.

In view of the importance of summer heat and low rainfall under the climatic conditions characteristic of Sweden, it is obvious that the most successful fruit-growing sections should be found in those parts of the country where the mean summer temperatures are the farthest above a safe minimum, the mean summer rainfall well below a safe maximum, and where all climatic factors experience the least annual deviation above and below their means. The highest summer temperatures in Sweden are found in the extreme south, and the mini-

mum deviations from the means are in the coastwise plains under the influence of the seas. It is undoubtedly for these reasons that the best fruit zones of Sweden are located in the extreme southern, southwestern and southeastern coastal plains.

Winter Extremes

The winters of Sweden, particularly in the southern third of the country, are not nearly as cold as is ordinarily supposed. Winter extreme temperature as a factor in apple production there is, at best, secondary in importance to growing season conditions. While winter injury is by no means rare it seldom occurs as the result of extreme cold alone; usually being experienced as the result of moderate cold following an unfavorable summer and fall season.

In the earlier days of the commercial apple industry of Sweden, from fifty to a hundred years ago, there was a tendency to favor the introduction of the hardier varieties of Russia. Later developments have shown, however, that the greatest need of the country is for varieties that will thrive and bear well under the cool and sometimes rainy seasons and which, following such seasons, can tolerate winters of moderate severity. The Gravenstein and Akero, the two leading commercial varieties, meet this requirement.

Conditions in the Far North

Apples can be grown with some degree of success in the coastwise regions of Sweden almost as far north as the head of the Bay of Bothnia, 65° 50′ North Latitude. Of the several species of apples under cultivation the Asiatic crabs, *Pyrus baccata* and *P. prunifolia*, are the most successful in the north, but their fruit is so small and inferior as to be of little worth. An occasional tree of *Pyrus malus* is to be found at times farther north than the baccata and prunifolia, but only some distance south of its extreme limit can it be depended upon for more than an occasional crop of mature fruit. Wulff reports an apple tree of the species malus at Luro, North Latitude 66° 26′, which is said to blossom every year but the fruit always drops before mature. Birger reported from Pajala, North Latitude 67° 11′, a tree (also *P. malus*) about 15 years old and growing without any protection, which blossomed almost every year and occasionally bore fairly well matured fruit. This probably marks the extreme northern limit at which there is any authentic record of the fruiting of *Pyrus malus*. Pajala is 41 minutes north of the polar circle. It has a summer mean temperature of 55° and a winter mean of 8.°

In progressing north from the upper limits of commercial fruit production in Sweden the different varieties of apples are found to respond to the changing conditions of climate in different ways. Some varieties yield first to the more severe winters while others can tolerate the winters but fail to mature their fruit. Some varieties suffer principally from injury to the fruit due to summer frost after the period of continuous daylight is past. In a number of the hardiest varieties of the extreme north, notably Borovinka and a few sweet apples, heavy crops are borne but the fruit is inclined to be insipid or bitter. Rarely do any of the tree fruits in the far north suffer from

late spring frosts. The mass of ice and snow remaining from the winter retards the development of vegetation until so late in the season that by the time the blossoms appear the danger of frost is well past.

The most interesting and valuable experimentation with tree fruits in the far north has been conducted near Pitea, on the east coast of Sweden at latitude 65° 19′. The work at Pitea, which has included variety testing of apples, pears, cherries and small fruits, was started in 1870 by L. A. Ringius, and has been continued up to the present time. Surprising success has been attained there with a number of apple varieties, notably the Alexander, Charlamoff, Wealthy, Safstaholm, Skvosnoi Naliv, Transparente Blanche, and Large Clear Astrachan. Wealthy has proved one of the best and hardiest.

In view of the low total summer temperature and the short growing season characteristic of the northern coastal region the fair success with apples at Pitea must be attributed principally to low summer rainfall, a high percentage of sunshine, and a July mean temperature considerably above that which would normally be expected for so high a latitude. An interesting contrast can be drawn between Pitea and Sitka, Alaska, where the mean temperature for the five-months period from May to September inclusive is precisely the same as at Pitea, but where the July mean temperature is 5° lower and summer rainfall very much heavier. The production of apples at Sitka has met with practical failure except during an occasional summer of abnormally low rainfall and of temperatures well above the average.

The exceptional season of 1900 at Pitea in contrast with that of 1922 at Sitka adds further emphasis to the importance of rainfall in relation to the low summer temperatures of the high latitudes. The summer of 1900 at Pitea was characterized by abnormally low temperatures, both the growing season mean and the highest monthly mean being below those recorded at Sitka in 1922. However, the low temperatures at Pitea were accompanied by a summer rainfall more than 30 percent below the average, with the result that a number of the apple varieties growing there at that time had matured their crops normally by the latter part of September. At Sitka in 1922 with far more favorable temperature conditions but with excessive rainfall, all varieties failed.

Under the trying climate of the north the importance of minor variations of a local nature is greatly accentuated. The benefits of the greater warmth and protection of a southern exposure are often sufficient to ripen nicely a crop of fruit which would have failed to mature on a less favorable site in the same locality. Even more pronounced are the effects of training trees against the southern aspect of a wall, this making possible the successful culture of fruits much farther north than would be possible were the trees fully exposed on all sides. In Norway peaches without protection can not be ripened successfully even in the southernmost parts, but when the trees are trained on espaliers facing the south the fruit ripens in warm summers as far north as 61° 17′. The Large Clear Astrachan, a native apple variety, ripens in southern Sweden about September 15, but Ringius writes that at Pitea "after a favorable season the very largest, most beautiful and fully ripe fruits of the Large Clear Astrachan, from trees trained against a south wall, are harvested by September 1."

Effect of Storage Temperature on Soggy Breakdown of Golden Delicious Apples

By H. H. PLAGGE, *Iowa State College, Ames, Iowa.*

THE low-temperature breakdown of apples noted by Plagge (3), Kidd and West (1), and McClelland and Tiller (2), and named "soggy breakdown" by Plagge and Maney (4), has been found to be prevalent in Golden Delicious. Soggy breakdown on Golden Delicious frequently resembles soft-scald as commonly noted on Jonathan and Northwestern Greening. While some specimens show only tissues resembling soft-scald lesions, others show both soft-scald and soggy breakdown injuries. Still other specimens have only typical soggy breakdown tissue.

Soggy breakdown on Golden Delicious was first noted in 1925. Due to the close similarity of the necrotic tissues to soft-scald, the disease was not recognized under the new name until the following season when experimental evidence was obtained to show that the disorder was soggy breakdown. The disease now appears to be of considerable commercial importance.

The principal basis for the foregoing statements is the evidence given in Table I. The fruit used in the experiments was fully mature, of excellent quality, and of good size. The apples were packed in standard apple boxes and wrapped in oiled paper. The unit for each test was one box of fruit. The apples were sized and packed with numerical count ranging from 88 to 125 per box. Storage temperatures of 30°, 32°, 34°, and 36°F. were maintained within ± 0.5°F.

TABLE I—EFFECT OF STORAGE TEMPERATURE ON SOGGY BREAKDOWN OF GOLDEN DELICIOUS

Year	Picking Date	Lot No.	No. Days Delay	No. Weeks in Storage	Percentage of Soggy Breakdown				
					Cold Storage Degrees F.				Air Cooled Storage
					30°	32°	34°	36°	
1925	Sept. 20	1	3	23	0.0	0.0	0.0	0.0	0.0
1925	Sept. 20	2	20	20	—	48.9	—	—	—
1926	Oct. 6	1	15	12	48.8	27.1	17.8	0.0	0.0
1927	Oct. 13	1	1	17.5	0.0	0.0	0.0	0.0	0.0
1927	Oct. 13	2	7	16.5	12.0	0.0	0.0	0.0	0.0
1927	Oct. 13	3	14	15.5	73.8	26.7	2.1	0.0	0.0
1927	Oct. 13	4	21	14.5	58.1	42.4	22.5	0.0	0.0

The relative humidity was 85 percent in each storage room. In 1925 the condition of the fruit was recorded on March 1; and for 1926 and 1927, on February 14. With the exception of 1925, which was early, the picking dates were considered about right for the variety. A preliminary inspection of some of the fruit in 1927 revealed the presence of soggy breakdown as early as January 27.

In 1925, soggy breakdown occurred only on fruit which was delayed 20 days and then stored at 32°F. All other lots of apples which were stored 3 days after picking kept satisfactorily under all 4 temperatures and in common storage.

In 1926 the fruit was delayed 15 days and the results were somewhat more conclusive. This fruit showed 48.8, 27.1, 17.8, 0.0 and 0.0 percent soggy breakdown at 30°F., 32°F., 34°F., 36°F., and in common storage respectively. These data strongly suggest the susceptibility of Golden Delicious to soggy breakdown at temperatures of 30° to 34°F., especially on fruit which has been delayed before storing.

In 1927, 20 boxes of apples were picked and packed on October 13. These were sent to Ames by express and arrived there the next day. Five boxes (Lot No. 1, Table I) were stored at once, one box at each of the four cold storage temperatures employed, and one box in common storage. The other 15 boxes were placed in an open apple packing shed with exposure to ordinary temperatures, but shaded from the direct sunlight. Seven days later, after the picking date, 5 more boxes (Lot No. 2, Table I) were stored, 1 box at each of the four cold storage temperatures employed and 1 box in common storage. The same procedure was carried out for lots No. 3 and 4, lot 3 being stored 14 days after picking and lot 4, 21 days after picking. The cold storage and common storage temperatures were the same as those maintained in 1925 and 1926.

The results show conclusively the detrimental effect of storing Golden Delicious apples at 30° to 34 °F. after the fruit has been delayed. With immediate storage no soggy breakdown occurred under any of the storage temperatures, but with 7 days delay it occurred at 30°F., and with 14 days delay and 21 days delay it occurred at 30°, 32° and 34°F. It is of particular interest to note the non-occurrence of soggy breakdown, regardless of when fruit was stored, at 36°F. and in common storage. The temperatures of the common storage room were never below 35°F. Almost without exception, the susceptibility of Golden Delicious to soggy breakdown increased as the storage temperature was lowered and as the delayed storage period was lengthened.

Conclusions

The Golden Delicious became very susceptible to soggy breakdown at the usual cold storage temperatures employed, unless the fruit went into storage immediately after it was picked. Since immediate storage is not always practical and other factors, as time of picking and season, may alter the susceptibility to soggy breakdown, the storage temperature of 36°F. is considered the most desirable for Golden Delicious. The susceptibility of Golden Delicious to soggy breakdown increased in a rather definite proportion to the lowering of the storage temperature and also to the lengthening of the delayed storage period. No disadvantages of storing Golden Delicious at 36°F. were evident when the fruit was sound and wrapped in oiled paper.

Literature Cited

1. Kidd, F., and West, C. Functional diseases of apples in cold storage. Dept. Sci. and Indus. Res., Food Invest. Bd. Spec. Rpt. 23. 1925.
2. McClelland, N., and Tiller, L. W. Cold storage investigations, Season 1925. Cawthron Institute, Nelson, N. Z. 1925.
3. Plagge, H. H. Soft-scald and breakdown of apples as affected by storage temperature. Proc. Am. Soc. Hort. Sci., 22:58–66. 1925.
4. Plagge, H. H., and Maney, T. J. Soggy breakdown of apples and its control by storage temperature. Ia. Agr. Exp. Sta. Res. Bul. 115. 1928.

Some Results of Flesh Texture Tests with Peaches

By M. A. Blake, *Experiment Station, New Brunswick, N. J.*

DURING the summer of 1928, a series of studies were made upon the texture of peach fruits. The more important objectives were as follows:

(1) To learn the comparative value of a so-called "needle" plunger and those of larger sizes in the determination of fruit textures; (2) the development and construction of a mechanical device as an aid to commercial peach growers and inspectors in the determination of proper textures of the peach for shipping and marketing; (3) a study of texture tests of the fruit made through the skin, as compared to tests made with the skin removed; (4) the determination of the relative accuracy of the color method of judging texture and maturity; (5) the determination of the variations in skin and flesh texture of different types of peaches, as for example, the canning-fleshed clingstones and the melting-fleshed types; and (6) a study of the relation of the growth status of the trees to the flesh texture of the fruit.

Results with Plungers of Different Sizes

The so-called "needle" tester which was used in these investigations consisted of a wire having a diameter of .032 inches and the pressure required to penetrate the fruit was recorded in grams. A slightly rounded plunger of $\frac{3}{16}$ inch diameter was used to test the maturity of ripening fruits in numerous cases, and, to some extent, the texture of the flesh of green fruits. A slightly rounded $\frac{5}{16}$ inch plunger was employed almost entirely for determining the comparative texture of fruits tested with the skin on and with the skin off at the time of maturity.

The needle plunger appeared to be quite satisfactory for determining the relative texture of small green fruits. Plungers with a diameter of $\frac{5}{16}$ inch required much more pressure, caused cracking and splitting of the fruit, and did not appear to have any advantage over the needle plunger for work with small green fruits. The testing of the texture of shipping ripe or mature specimens was regarded as a somewhat different matter, however. From a shipping standpoint, it is important to know to what degree a certain variety of fruit of a given maturity will successfully withstand the pressures to which it is likely to be exposed in shipment and distribution. It seems clear that

even very hard fruit may be punctured by nail points in baskets or elsewhere, and therefore, it is of more practical value to determine the extent to which fruits of a certain variety and maturity will resist a bruising type of pressure.

At the very beginning of the peach ripening season, it was considered desirable to determine the relative effects of using a needle tester in comparison with one of $\frac{5}{16}$ inch diameter. To make this comparison as fair as possible, five fruits of a variety as uniform in maturity as could be determined by skin color were first selected. Five tests with a needle plunger were then made at five different points upon each peach. Five similar tests with a $\frac{5}{16}$ inch plunger were then made as near as possible to the points upon the fruit where the needle tests occurred, but far enough from them so that the second test would not be affected by the first. The results obtained upon three varieties, Rochester, Carman, and Paragon, are given for illustration.

TABLE I—Comparative Results with Needle and 5/16 Inch Plunger

Variety	Condition	.032 Plunger	5/16 Plunger	
			Skin On	Skin Off
Rochester	Green Ripe	209 grams	14.9 lbs.	10.2 lbs.
Carman	Firm Ripe	210 "	10.7 "	6.2 "
Paragon	Nearly Soft Ripe	210 "	6.6 "	3.6 "

The tests through the skin with the needle plunger indicated that these three varieties were similar in texture at the time they were tested. On the other hand, the tests made with a $\frac{5}{16}$ inch plunger indicated a decided difference between them. The flesh of Paragon was in a good edible condition when tested while that of Rochester was distinctly greenish and hard.

Apparently, a plunger larger in diameter than what might be termed the needle type, is more likely to prove satisfactory for determining the degree of maturity and texture of peach fruits that have reached the shipping or edible stage. Comparative tests made with the "needle" plunger, a $\frac{3}{16}$ inch and a $\frac{5}{16}$ inch, indicate that the larger the plunger, the more likely it is to accurately record slight differences in texture. It was found, however, that a pressure of 20 pounds or more was sometimes required to force a $\frac{5}{16}$ inch plunger through the skin and flesh of fruit that had reached what might be termed a green shipping stage. Since one objective was to develop a simple form of pressure tester adapted to the use of orchard foremen, fruit inspectors, and others employed in the harvesting and marketing of peaches, it was desirable to use a plunger of a smaller size, requiring less pressure to operate, if this could be done without sacrificing accuracy.

A few tests made upon the fruits of several varieties of peaches selected at random are given for comparison. All tests were made through the skin.

The $\frac{3}{16}$ inch plunger is apparently as accurate as the $\frac{5}{16}$ inch for indicating the relative texture of the fruit of different varieties in various stages of maturity, from a well-developed but still green stage,

to a soft ripe condition. For tests of the flesh of ripe fruit with the skin removed, however, the $\frac{5}{16}$ inch plunger is more desirable and even necessary.

TABLE II—COMPARATIVE RESULTS WITH 3/16 AND 5/16 INCH PLUNGERS

Variety	Condition	3/16 Inch	5/16 Inch
Kathryn	Firm Ripe	5.93	10.18
Kathryn	Hard Ripe	7.39	14.92
Kathryn	Shipping Ripe	7.60	15.28
Billmeyer	Shipping Ripe	6.25	14.50
Eclipse	Firm, Soft	3.71	7.05
Elberta	Firm, Soft	3.82	7.45
Elberta	Shipping Ripe	7.77	16.76
Elberta	Still Greenish	8.60	20.33

Since a $\frac{3}{16}$ inch plunger proved to be large enough to determine accurately the texture of peaches from the preshipping stage to soft ripe, a small simple testing apparatus was devised which only requires a range of pressure of from one to 15 pounds, and can easily be carried about by an orchard foreman or fruit inspector. A device with a wider range of pressure may be desirable for experimental work, however.

THE SKIN AS A FACTOR IN TEXTURE TESTS

The question may be raised as to whether tests for fruit maturity to determine its condition for shipping should be made with the skin on or with the skin removed. Fresh fruit is always shipped with the skin on, and this is undoubtedly a factor in shipping quality.

A large number of tests of different varieties of peaches were made with a $\frac{5}{16}$ inch plunger through the skin and with the skin removed. From the standpoint of the commercial shipping of fresh fruit, tests through the skin require less time and are apparently as satisfactory for the purpose desired as are tests made through the flesh. From a canning standpoint, however, it is likely that tests of the flesh with the skin removed may prove more accurate and satisfactory than tests made through the skin.

A large number of tests were made with a $\frac{5}{16}$ inch plunger upon fruits of Elberta through the skin and with the skin removed. A few of the results selected at random will serve to show the relative toughness of the skin at various stages of fruit maturity.

TABLE III—RELATION BETWEEN MATURITY AND TOUGHNESS OF SKIN

Lot	Through Skin	Skin Removed	Difference
1 Soft Ripe	5.55	3.05	2.50
2	6.08	3.51	2.57
3	7.03	4.17	2.86
4	8.76	5.50	2.97
5	13.17	8.20	4.97
6	16.13	11.13	5.00
7	19.62	13.20	6.42
8 Still Green	19.67	13.27	6.40

It is apparent that, as the fruit softens from a green shipping condition to edible ripe, the difference in texture, between the flesh and the skin and flesh combined decreases. In the case of the Elberta fruits cited, the difference ranges from 6.4 pounds in the more green fruit, to 2.5 pounds in case of the soft ripe.

The Color Method of Determining Fruit Maturity

For many years, the basis of judging the maturity of peaches for shipping and marketing has been the so-called "under color." When the fruit of any variety enters the ripening stage, the green under color usually changes from the shade of green of immature fruit to a greenish white or yellow, and perhaps later, to a clear cream white or orange yellow.

The color change in some varieties is delayed until rapid softening begins, and when little or no green can be detected in the under color, the fruit is almost certain to be soft, melting ripe. On the other hand, some varieties like J. H. Hale and Eclipse of the melting flesh type may lose all of the green tints in the under color, while the fruit still remains in a firm condition satisfactory for shipping some distance.

Variations in the Test

If each variety were consistent in the correlation of color change to maturity, the problem would not be especially difficult, but unfortunately, at least from the standpoint of the orchardist, it is not. When a tree of a variety such as Belle is highly vegetative, the green shade of under color of the fruit may remain until the fruit is soft ripe. In other words, the growth status of the tree is a factor in the correlation of under color to texture. A further confusing factor is that fruit of the same shade of color upon the same tree may vary markedly in texture.

Experienced peach growers have good reasons for knowing that the extended lip-like sutures of some varieties of peaches become soft before the cheeks do. This is true of St. John, Early Crawford, Mountain Rose, and many others. Tests at New Brunswick during the summer of 1928 substantiated this fact but revealed further that while the fruit was still firm, the texture of even the most prominent part of a "lipped" suture was as resistant to pressure as the cheeks of the fruit. Contrary to quite general belief, the most tender section of the fruit of many varieties was the upper dorsal region near the stem and extending down to near the middle of the fruit. This area is usually somewhat flattened and often unmarked by a suture line, in contrast to the deep suture line near the stem attachment upon the opposite side of the fruit.

Although the fact is more or less generally known and understood that marked variations in texture are found between fruits of different varieties of peaches at approximately the same stage of maturity, it may be well to make brief mention of the fact in such a discussion as this.

It is not possible, for example, to set a texture standard in terms of seven pounds of pressure exerted by means of a $\frac{3}{16}$ inch plunger and

to a soft ripe condition. For tests of the flesh of ripe fruit with the skin removed, however, the $\frac{5}{16}$ inch plunger is more desirable and even necessary.

TABLE II—COMPARATIVE RESULTS WITH 3/16 AND 5/16 INCH PLUNGERS

Variety	Condition	3/16 Inch	5/16 Inch
Kathryn	Firm Ripe	5.93	10.18
Kathryn	Hard Ripe	7.39	14.92
Kathryn	Shipping Ripe	7.60	15.28
Billmeyer	Shipping Ripe	6.25	14.50
Eclipse	Firm, Soft	3.71	7.05
Elberta	Firm, Soft	3.82	7.45
Elberta	Shipping Ripe	7.77	16.76
Elberta	Still Greenish	8.60	20.33

Since a $\frac{3}{16}$ inch plunger proved to be large enough to determine accurately the texture of peaches from the preshipping stage to soft ripe, a small simple testing apparatus was devised which only requires a range of pressure of from one to 15 pounds, and can easily be carried about by an orchard foreman or fruit inspector. A device with a wider range of pressure may be desirable for experimental work, however.

THE SKIN AS A FACTOR IN TEXTURE TESTS

The question may be raised as to whether tests for fruit maturity to determine its condition for shipping should be made with the skin on or with the skin removed. Fresh fruit is always shipped with the skin on, and this is undoubtedly a factor in shipping quality.

A large number of tests of different varieties of peaches were made with a $\frac{5}{16}$ inch plunger through the skin and with the skin removed. From the standpoint of the commercial shipping of fresh fruit, tests through the skin require less time and are apparently as satisfactory for the purpose desired as are tests made through the flesh. From a canning standpoint, however, it is likely that tests of the flesh with the skin removed may prove more accurate and satisfactory than tests made through the skin.

A large number of tests were made with a $\frac{5}{16}$ inch plunger upon fruits of Elberta through the skin and with the skin removed. A few of the results selected at random will serve to show the relative toughness of the skin at various stages of fruit maturity.

TABLE III—RELATION BETWEEN MATURITY AND TOUGHNESS OF SKIN

Lot	Through Skin	Skin Removed	Difference
1 Soft Ripe	5.55	3.05	2.50
2	6.08	3.51	2.57
3	7.03	4.17	2.86
4	8.76	5.50	2.97
5	13.17	8.20	4.97
6	16.13	11.13	5.00
7	19.62	13.20	6.42
8 Still Green	19.67	13.27	6.40

Elberta fruits at the pit-hardening stage may resist pressures with an .032 needle amounting to 450 grams or more. When the fruits of this variety attain a soft ripe condition, however, the pressure resistance may be reduced to 200 grams or less, and right here the research worker encounters serious difficulties.

It is an established fact that the time of the ripe stage of a variety of peach may be varied from not less than five to ten days by varying the growth status of the tree. It is further known that texture may be influenced by temperature and that the texture of the first lot of fruit picked from a tree may vary from that of a second lot picked some days later.

It becomes apparent that unless the fruit from trees under two different treatments is picked at exactly the same stage of maturity, comparisons as to texture are futile. Since in the case of peaches, the texture change may sometimes be a matter of pounds within 24 hours, how can one be certain that he is making a true comparison between two lots of fruit that may ripen from one to ten days apart, if he cannot depend upon the color method for estimating degree of maturity?

These factors will be the despair of many who will try to correlate orchard nutrition with fruit texture, and the appearance of confusing and contradictory data upon this point is assured.

Although a considerable number of flesh texture tests were made at New Brunswick in 1928 of mature fruits from trees of varying growth status, it is too early to draw conclusions upon this phase of the problem.

It would seem highly probable, however, that this problem should be attacked on the basis of the growth status of the tree on the assumption that trees of the same variety that exhibit a like quality of growth will produce fruits that are of like quality. The assimilated organic materials in a plant must ultimately determine the status of sexual and vegetative response. If a given unit of inorganic nitrogen is assimilated, it must have the same effect upon the tree, whether procured from ammonium sulfate, nitrate of soda, manure, or green crops. Likewise, an equal decrease in percentage of metabolic carbohydrates will have a similar influence upon the quality of fruits and vegetative structure, whether the decrease be induced by heavy pruning, cloudy weather, or other factors, as equal increase in the percentage of metabolic carbohydrates should also have a similar influence upon the fruit and vegetative structure whether induced by lack of moisture, lack of pruning or other conditions of environment.

Ripening and Composition of the Texas Magnolia Fig. Preliminary Report*

By Hamilton P. Traub and G. S. Fraps, *Experiment Station, College Station, Texas.*

FIG production is one of the major horticultural industries in Texas. The state ranks first in the output of canned and preserved figs. The Magnolia, an excellent canning and preserving sort, is the chief variety grown commercially in the State. The origin of the Magnolia is obscure. Condit (1927) claims that it is identical with Brunswick, but the Magnolia differs markedly from the variety described by Gould (1923) and known as the Brunswick in Texas. Some of the more apparent differences are shown in Figs. 1a, 1b and 1c.

The present study was undertaken to answer practical questions confronting the fig canning industry:—(1) The food value of the fig, carbohydrates, protein, fats, ash, and vitamin contents; (2) other qualities, size, shape, number of seeds, etc.; (3) the stage in the development when it is most profitable to harvest the fruit from the standpoint of the canner. The study is equally important in providing a basis for work in the fertilizer requirements and breeding of the fig. Additional information on the ripening process in fruits is a by-product.

Material and Methods

The fruit utilized in the study of the ripening process in figs were gathered from the orchard on the Main Horticulture Farm at College Station. The fruits were tagged when just emerging at the leaf axil, and those utilized were, therefore, of approximately the same age. It was observed, however, that a small per cent of the fruits showed marked individuality indicating that other factors besides the time factor were operative. The fruits for the study of the commercial grade were collected from July to September from six localities in Galveston, Harris, Brazoria, and Jefferson counties of the Upper Gulf Coast,† the chief commercial fig region of the State. The fruits were taken from the regular commercial grade at random. Two baskets, 10x6½x4 inches, containing approximately 54 figs each were used as a sample.

The methods of the Association of Official Agricultural Chemists were used for most of the determinations. The small stems were removed from the figs and the entire fig (including the skin) ground thru a food chopper and thoroly mixed. Samples were immediately weighed for analysis. Water was run on 5 grams dried in a vacuum at 70 degrees; protein on 8.75 grams by the Gunning method; ether extract, by extraction of the dried material with ethyl ether; crude fiber on 5 grams by the usual method; sugars by the Munson and Walker method; pentosans on 10 grams by the phloroglucin method; lime, magnesia and insoluble ash on 40 grams by the usual method;

*Published with the approval of the Director as Contribution No. 431 of the Journal Series of the Texas Agricultural Experiment Station. (Scientific Paper No. 44, Division of Horticulture.)

†Thanks are due the Texas Fig Inc. who furnished this material.

Elberta fruits at the pit-hardening stage may resist pressures with an .032 needle amounting to 450 grams or more. When the fruits of this variety attain a soft ripe condition, however, the pressure resistance may be reduced to 200 grams or less, and right here the research worker encounters serious difficulties.

It is an established fact that the time of the ripe stage of a variety of peach may be varied from not less than five to ten days by varying the growth status of the tree. It is further known that texture may be influenced by temperature and that the texture of the first lot of fruit picked from a tree may vary from that of a second lot picked some days later.

It becomes apparent that unless the fruit from trees under two different treatments is picked at exactly the same stage of maturity, comparisons as to texture are futile. Since in the case of peaches, the texture change may sometimes be a matter of pounds within 24 hours, how can one be certain that he is making a true comparison between two lots of fruit that may ripen from one to ten days apart, if he cannot depend upon the color method for estimating degree of maturity?

These factors will be the despair of many who will try to correlate orchard nutrition with fruit texture, and the appearance of confusing and contradictory data upon this point is assured.

Although a considerable number of flesh texture tests were made at New Brunswick in 1928 of mature fruits from trees of varying growth status, it is too early to draw conclusions upon this phase of the problem.

It would seem highly probable, however, that this problem should be attacked on the basis of the growth status of the tree on the assumption that trees of the same variety that exhibit a like quality of growth will produce fruits that are of like quality. The assimilated organic materials in a plant must ultimately determine the status of sexual and vegetative response. If a given unit of inorganic nitrogen is assimilated, it must have the same effect upon the tree, whether procured from ammonium sulfate, nitrate of soda, manure, or green crops. Likewise, an equal decrease in percentage of metabolic carbohydrates will have a similar influence upon the quality of fruits and vegetative structure, whether the decrease be induced by heavy pruning, cloudy weather, or other factors, as equal increase in the percentage of metabolic carbohydrates should also have a similar influence upon the fruit and vegetative structure whether induced by lack of moisture, lack of pruning or other conditions of environment.

per fruit in grams; length and width of fruit in millimeters, and number of seeds per fruit.‡ Seeds in 150 fruits were counted by the following method: the whole fruit was cut into thin longitudinal slices which were placed on sheets of paper to dry; the seeds were then crushed with a tweezers held in the right hand, and the number was recorded on a tally counter held in the left hand. This method is illustrated in Fig. 1d. The data have been subjected to statistical analysis.

Ripening Process

In this study figs were analyzed in five successive stages of development, "very small green" (20x18mm.), "small green," (27x20 mm.), "large green" (30x29mm.), "commercial grade," (34x38mm.), and in the "tree ripe" condition. The results are shown graphically in Figs. 2a, 2b, 2c and 2d. Fig. 2a shows that on a dry weight basis, the sugars reach a maximum in the "tree-ripe" condition but the rate of increase after the "commercial stage" is reached is slowed down so much that the additional increase would not justify the practice of deferring the harvesting. Altho the pentosan and protein content in proportion to the carbohydrates declines with maturity as shown in Fig. 2a, there is a total increase of pentosans and proteins per single fruit as shown in Fig. 2b. There is a decrease in "residual nitrogen free extract"§ on both a dry weight basis and per single fruit showing that part of the hexosans are transformed into sugars. The difference between the increase in the total sugar increase and the decrease in "residual nitrogen free extract" can be accounted for only by a rapid transportation of sugars from the leaves during the time which elapses between the "large green" stage and "commercial grade" stage.

On a dry weight basis as shown in Figs. 2c and 2d, there is a decrease of crude lipides (ether extract), total ash, insoluble ash, lime, phosphoric acid, and magnesia in proportion to the carbohydrates, but per single fruit there is an absolute increase of these constituents. In the case of potash the increase is approximately proportional to the increase in carbohydrates as shown in Figs. 2c and 2d. Analyses of iron content of large green and tree-ripe fruit on a dry weight basis show .008 and .007 per cent (.0015 and .0018 on a fresh weight basis) respectively.

Mature Fruit

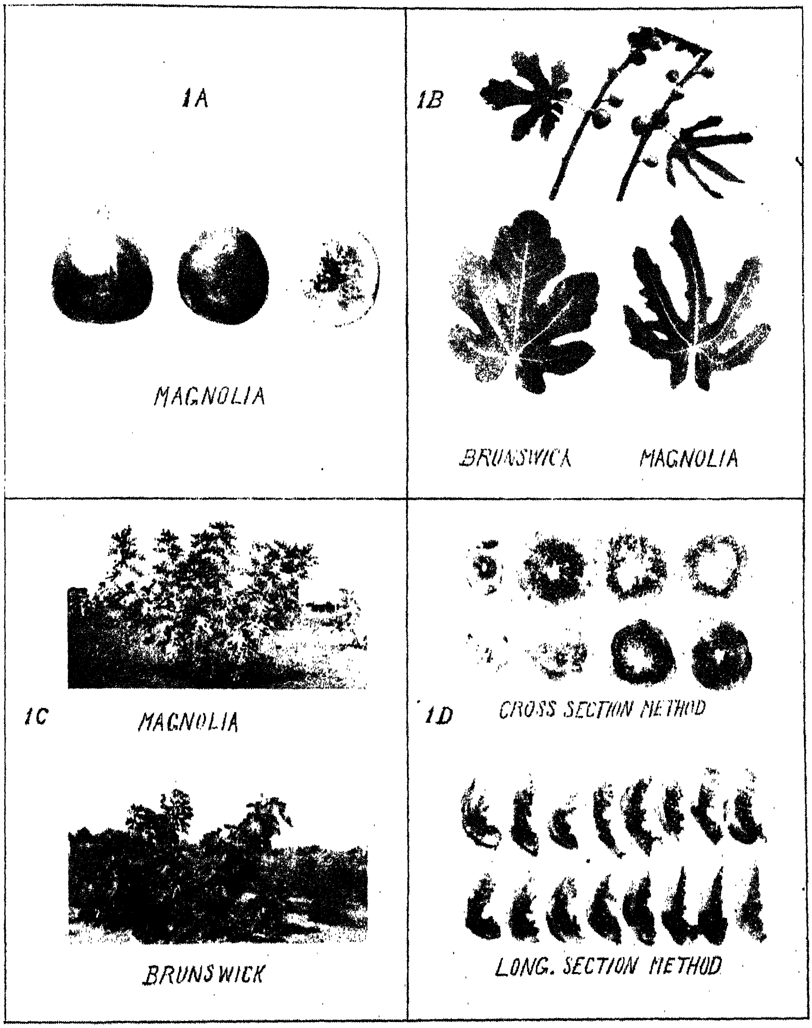
The constants for the commercial grade of the Magnolia fig have been summarized in Table I.

The chemical analyses reported in this paper are not strictly comparable with those reported by other workers|| since these latter

‡Special acknowledgment is due Miss Lillian Gorzycki for competent assistance in the laboratory.

§The value for the "residual nitrogen-free extract" is used as an estimate of the acid hydrolyzable hexosans. 100-Σ (Proteins, fats, crude fiber, water and ash) = Nitrogen free extract. "Residual nitrogen free extract" = nitrogen free extract—Σ (sugars and pentosans).

||Chemical analyses of the Dottato fig are not numerous. Colby (1894) reports analyses of various varieties of the fig not including Dottato (Kadota). Pellicano (1907), Guglielmi (1908) and Rossi (1912) report analyses of the Dottato (Kadota) fig; Condit (1927) summarized analyses of the Dottato (Kadota) fig by various workers.



Commercial grade Magnolia fruit (Figure 1a); Magnolia and Brunswick, comparison of bearing habit, and leaves (Figure 1b); and whole plant (Figure 1c); methods of counting seeds in figs (Figure 1d).

are expressed on a fresh weight basis and the methods of analysis are not indicated. However, we have taken the liberty of expressing the data of several workers on a dry weight basis, and these together with other constants are then compared in Table II with the analyses of "tree-ripe" fruit from College Station. The agreement between the sugar content of our samples and those of the other two workers quoted is remarkably close, while the others agree remarkably well considering the wide distance separating the place of growth of the figs. This is not the region of optimum development of the fig in Texas and represents a conservative position.

TABLE I—COMPOSITION OF THE MAGNOLIA FIG.

Upper Gulf Coast Region (Harris, Galveston, Brazoria, and Jefferson Counties) and College Station, Brazos County. Season 1928.

Chemical Composition
Gulf Coast Region

	Per cent Fresh Weight			Per cent Dry Weight		
	Mean	S. D.	C. V.	Mean	S. D.	C. V.
Dry matter	16.8 ±0.1	0.6	3.9			
Total Sugars	11.8 ±0.1	0.5	4.9	70.0 ±0.3	1.6	2.3
Reducing Sugars	11.3 ±0.1	0.5	5.0	67.1 ±0.3	1.8	2.8
Pentosans	1.02			6.0		
Crude Fiber	1.0 ±0.01	0.1	9.3	6.5 ±0.1	0.5	8.6
Protein	0.7 ±0.02	0.1	16.1	4.6 ±0.15	0.8	17.6
Crude Lipides	0.08±0.01	0.06	76.7	0.5 ±0.07	0.4	82.4
Total Ash	0.4 ±0.01	0.07	16.2	2.5 ±0.7	0.3	15.0
Insoluble Ash	0.02±0.002	0.005	21.8	0.15±0.01	0.03	24.8
Lime (CaO)	0.06±0.001	0.005	7.4	0.4 ±0.01	0.03	1.8
Phosphoric Acid (P_2O_5)	0.03±0.0005	0.0007	2.3	0.19±0.002	0.007	3.9
Iron (Fe)	0.0027			0.01		
Potash (K_2O)	0.15±0.01	0.03	19.9	0.9 ±0.06	0.1	18.1
Magnesia (MgO)	0.03±0.001	0.005	15.1	0.19±0.01	0.03	17.0

Various Constants

	Gulf Coast Region				College Station, (Brazos County)			
	No. Individuals	Means	S. D.	C. V.	No. Individuals	Mean	S. D.	C. V.
Whole fruit gms.	170	35.1± 0.3	6.9	19.7	93	29.6±0.3	5.1	17.3
Skin per fruit gms.	120	4.5± 0.1	0.2	6.2				
Volume per fruit cc.	170	35.0± 0.3	6.9	19.7	93	29.6±0.3	5.1	17.3
Length per fruit mm					100	34.5±0.2	3.4	10.1
Width per fruit mm					100	38.2±0.2	2.9	7.7
Number of Seeds	150	406.0±10.0	182.1	44.8				

CONCLUSIONS

1. The ripening process in the fruit of the Magnolia fig has been detailed in terms of changes in the carbohydrates, nitrogen, lipide and ash fractions.

2. Constants characteristic of the commercial grade of the Magnolia fig are given.

3. A method for counting seeds in figs has been described.

4. The practice of harvesting the fig shortly before it is tree-ripe for canning has been justified by these results since the net gain in sugars and other constituents after the commercial stage is reached, is not sufficient to warrant delay in harvesting.

5. The "tree-ripe" Magnolia fig compares favorably with the Dottato (Kadota) fig.

TABLE II—MAGNOLIA FIG COMPARED WITH THE DOTTATO (KADOTA) FIG

Chemical Composition

	Per cent Fresh Weight			Per cent Dry Weight		
	Traub & Fraps (1928)	Guglielmi (1908)	Rossi (1912)	Traub & Fraps (1928)	Guglielmi (1908)	Rossi (1912)
Moisture	74.8	20.3	18.0			
Dry matter	25.1	79.6	81.9			
Total Sugars	19.4		62.9	77.7		76.7
Reducing Sugars	18.2	58.4		72.5	73.3	
Non-Reducing Sugars	1.2			4.9		
Pentosans	1.0			3.9		
Crude Fiber	.9		4.0	3.7		4.9
Protein	1.3	5.2		5.2	6.5	
Ash	.6	2.3	2.7	2.3	2.9	3.2

Various Constants

	Magnolia	Dottato (Kadota)	
	Traub & Fraps (1928)	Pellicano (1907)	Condit (1920)
Per cent skin	14.7	51.8	
Per cent pulp	83.3	48.2	
Number of seeds	406 (Infertile)		505* (Fertile)

*Condit (1920), Average for counts of seeds in four caprified Dottato (Kadota) figs, made in 1917; 544, 412, 402, and 667 fertile seeds.

LITERATURE CITED

1. ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS. Official and tentative methods of analysis. 2nd ed. rev. July 1, 1924. Washington. 1925.
2. COLBY, GEO. F. Analyses of figs. (Sta. Bul. 102) in Calif. Agr. Expt. Sta. Ann. Rept. 1892–93 and part of 1894. pp. 225–235. 1894.
3. CONDIT, IRA J. Caprifigs and caprification. Calif. Agr. Expt. Sta. Bul. 319. 1920.
4. CONDIT, IRA J., and CRUESS, W. V. I. The Kadota fig. II. Kadota fig products. Calif. Agr. Exp. Sta. Bul. 436. 1927.
5. ELVEHJEM, C. A., and HART, E. B. Iron in Nutrition. II. Quantitative Methods for the determination of iron in biological materials. J. Biol. Chem., 67:43–51. 1926.
6. GOULD, H. P. Fig growing in the south Atlantic and Gulf states. U. S. D. A. Farmer's Bulletin 1031. 1923.
7. GUGLIELMI, G. Coltivazione industriale del fico nel Leccese. Bol. Arbor. Ital., 4:23. 1908.
8. PELLICANO, A. Il fico nel circondario di Gerace. Bol. Arbor. Ital., 3:140, 141. 1907.
9. ROSSI, FERDINANDO. Produzione dei Fichi in Italia. Annuario della R. Scuola Superiore d'Agricultura in Portici. 2:277–295. 1880. Quoted in A. Siniscalchi, La cultivazione del fico nel Cilento. Bol. Arbor. Ital.. 7:51. 1912.

The Relation Between Vessel Diameter and Flow of Water in the Xylem of the Apple

By J. R. FURR, *Cornell University, Ithaca, N. Y.*

THE trunk of an apple tree has a cross-sectional area smaller than the sum of the cross-sectional areas of the main branches which arise from it. This is illustrated by measurements of two trees, differing considerably in size: Tree A, area of trunk 223.0 sq. cm., sum of areas of (3) branches 251.0 sq. cm.; compared with Tree B area of trunk 718.3 sq. cm., sum of areas of (5) branches 877.3 sq. cm. Since this relationship is also true, in general, for any stem and its branches, it is obvious that the difference between the cross-sectional area of the trunk and that of the branches increases as cross-sections at higher and higher levels in the top are compared to the trunk. This relationship suggests that there is some variation in the efficiency with which tissues from different regions of the tree conduct the transpiration stream. That differences in efficiency of water conduction may exist is shown by studies, reported in this paper, on the anatomy of the xylem and flow of water in excised stems.

APPARATUS AND METHODS

The apparatus used to determine rate of flow by forcing water through stem segments consisted essentially of a filter for removing solid impurities, a water conduit of glass and rubber tubing with T-tubes at short intervals for attaching the stem segments to the apparatus, an open U-tube manometer attached to a T-tube in the conduit for indicating water pressure in the apparatus, and a device for controlling and maintaining the water pressure at a practically constant value.

The stem segments were attached to the T-tubes of the water conduit by short pieces of rubber tubing or, in the case of very large branch segments, by a "reducing joint," consisting of a large rubber tube fitted at one end with a one-hole rubber stopper and small glass tube. A series of these reducing joints was constructed so that stem segments of any size up to 9 cm. in diameter could be attached to the apparatus. Before attachment to the apparatus, the stems were cut into segments, usually 20 cm. long, and the ends trimmed with a sharp knife. Gases were removed from the vessels by placing the stems under water and exhausting with an aspirator, or by forcing water through them under pressure until gas bubbles no longer appeared. Connection tubes were attached to the stems under water, and water was allowed to flow from the T-tubes of the conduit while the stems were being attached to the apparatus so that all tubing was completely filled with water—thus the inclusion of air bubbles was prevented. All segments of a series were collected, prepared, and attached to the apparatus together so that certain factors not conveniently controlled, e.g., temperature, might affect alike the results which were to be directly compared.

The velocity of flow in stems was determined by Dixon's method slightly modified (1). A short piece of rubber tubing was fitted to the basal end of the stem so that it projected just beyond the end of the stem and formed a shallow basin. The gases were removed from the vessels and the stem kept wet while being fixed in a vertical position, with the basal end up and the apical end touching the surface of a weak ferric-chloride solution. Into the basin formed by the tubing, a weak potassium ferro-cyanide solution was placed, drop by drop as it disappeared into the stem. The appearance of the potassium ferro-cyanide solution at the lower (apical) end of the stem was indicated by the formation of a blue precipitate in the ferric-chloride solution. The time required for the passage of the solution through the stem was recorded with a stop watch.

Rate and Velocity of Flow in a Stem and Its Branches

Experiments on the rate of flow of water through segments of stems and the branches which arose from them were carried out to indicate whether or not a stem could conduct, at a given pressure, as much water as its branches. Stems with two or more branches originating near the same point were selected, and smooth 20 cm. segments of these were taken from near the point of their origin. These segments were set up as described above and water was forced through them at a pressure of 25 cc. of mercury. In the case of very large segments, 20 cm. of mercury pressure was used. The large thin-walled tubing used for connecting large segments to the apparatus was likely to burst at higher pressures.

Table I shows that (a) the volume of water conducted by a stem is greater than the sum of the volumes conducted by its branches; (b) the rate of flow per square centimeter of sapwood is greater for a stem than for its branches; and (c) the velocity of flow is greater in a stem than in its branches, that is, the time required to flow 20 cm. is less in a stem than in its branches.

These results suggest that there may be anatomical differences in the xylem of different regions, as, differences in diameter or length of vessels, which would in part account for the differences in rate and velocity of flow.

Anatomical Differences in Xylem of Different Regions

Measurements of vessels from different regions of a tree show that, in general, the average vessel diameter is greatest in the trunk and decreases gradually from trunk to terminals. In a 25-year-old Rhode Island Greening tree, for example, the average vessel diameter of the same season's growth was found to be 0.059 mm. in the trunk; in a 7-year branch, 0.041 mm.; in a 6-year branch, 0.035 mm.; in a 2-year branch, 0.032 mm.; and in a 1-year shoot, 0.023 mm.

Since it is true that, in general, the thickness of annual ring of any one season's growth is greatest at the base, or oldest part of the tree, and decreases towards the terminals, or the youngest part of the tree, the above data also suggest that large vessel diameter is associated with thick annual rings and small vessel diameter with thin annual rings.

This relation is further illustrated in a different way by the following measurements. In a Wealthy spur the radius of the 1925 annual

TABLE I—RATE AND VELOCITY OF FLOW IN STEM AND BRANCHES

1	2	3	4	5	6	7	8	9
Series	Stem (20 cm.) (Segments)	Age Branch Years	Area Cross Section Stem cm²	Area Cross Section Sapwood cm²	Volume Water Conducted in 30 Min. (cc.)	Sum of Volumes Conducted Branches	Rate cc. per Min. per cm² Sapwood	Velocity Time to Flow 20 cm. (Seconds)
1	Stem	3	0.442	0.411	97.0		7.834	588
	Branch	2	0.196	0.165	29.5		5.969	885
	Branch	2	0.189	0.158	19.6		4.135	930
	Branch	2	0.102	0.071	12.2	61.3	5.726	930
2	Stem	4	1.650	1.618	328.0		6.757	510
	Branch	3	1.230	1.119	198.0		5.546	579
	Branch	3	.503	0.472	71.0	269.0	5.014	790
3	Stem	4	1.896	1.865	414.0		7.733	466
	Branch	2 & 3	0.782	0.765	149.5		6.514	690
	Branch	2 & 3	0.512	0.481	72.0		4.756	954
	Branch	2 & 3	0.394	0.363	48.0		4.408	1026
	Branch	2 & 3	0.357	0.326	50.4	319.9	5.153	905
4	Stem	9	57.54	49.50	4675.0		6.296	
	Branch	8	38.54	32.81	2830.0		5.75	
	Branch	8	25.01	20.99	1650.0	4480.0	5.129	

ring was 0.36 mm., and the average vessel diameter was 0.011 mm.; while the radius of the 1928 annual ring was 2.11 mm., and the average vessel diameter was 0.025 mm. In a Northern Spy branch which showed unequal thickening of annual rings, the thick side of the ring had an average vessel diameter of 0.04 mm.; and the thin side of the ring, an average vessel diameter of 0.035 mm.

Additional evidence of this relation may be seen by referring to Tables II and III. The shoots in Table III are the same age but vary in diameter, and it is clear that the thickest shoot has the largest vessels and the thinnest shoot the smallest vessels. It appears therefore, that the correlation between vessel diameter and thickness of annual ring is closer than the correlation between thickness of annual ring and age of stem upon which the annual ring was formed. A one-year-old water sprout may thus have vessels of greater diameter than the same season's growth on older stems.

It is not necessarily true, however, that the stems with the largest vessels have the highest percentage of xylem occupied by lumen. Neither the number of vessels nor the proportion of vessels to other elements is constant in stems of a given age. Measurements in Table III illustrate this fact. It seems that the percentage of lumen is highest in the most vigorous shoots (A, B, C) and lowest in the least vigorous (D, E, F); but in segment A, taken from a shoot 138 cm. long, the percentage of lumen is lower than in segment B, taken from a shoot 109 cm. long.

Results of attempts to determine the length of vessels indicate that in the apple, vessels end only in undifferentiated tissue near the growing regions. Examination of material macerated with equal parts of 10 per cent nitric and 10 per cent chromic acids failed to reveal mature vessels ending in closed cross walls. Even spurs which had made annual length growths of only a few millimeters had no closed vessel ends in mature xylem. If vessel ends are to be found in mature xylem, they should be quite numerous in spurs where several years' growth is included in a short region. In spurs, vessel elements tapering to a point and overlapping like shingles on a roof were numerous; but in these cases the elements were connected laterally by a large open pore without a membrane. It seems safe to conclude that vessels of the apple extend, uninterrupted by closed cross walls, for considerable distances, probably from undifferentiated tissue in the root to undifferentiated tissue in the stem.

From the foregoing facts relating to the anatomy of the xylem, it seems that, in attempting to account for differences in rate and velocity of flow in stems, we should consider variation in vessel diameter, and, in the case of rate of flow, percentage of xylem occupied by lumen; but the length of vessels is so great that this factor may be disregarded.

Relation Between Velocity of Flow and Vessel Diameter

The results of experiments on the velocity of flow of potassium ferro-cyanide through stems show that the velocity is greatest in those which have the largest vessels and least in those which have

the smallest vessels. This is clearly shown by results obtained by the method previously described with shoots of the same age but of different average vessel diameter. With Rhode Island Greening one-year shoots, 125–150 cm. long, using five 10 -cm. stems, the average diameter of stem was 1.05 cm.; average diameter of vessel, 0.05 mm.; and average time to flow through 10 cm. segments, 170 seconds. With shoots 30–40 cm. long, using five 10-cm. stems, the average diameter of stem was 0.48 cm.; average diameter of vessel, 0.027 mm.; and average time to flow through 10-cm. segments, 353 seconds.

The velocity of flow in small, smooth cylindrical tubes is proportional to the square of the radii. When one applies this law to the above data, it becomes apparent that the velocity is only about two times as great in the shoots with large vessels as in those with small vessels instead of 3.3 times—the calculated value. Considering the possibilities for error and the fact that average diameters rather than the largest diameters are compared, the actual value approximates the calculated value closely enough to show that velocity of flow in vessels of the apple probably follows the physical law stated above.

Since it was found that, in general, diameter of vessel is associated with age of stem upon which the vessel is formed, it would be expected that velocity of flow is also associated with age. Velocity determinations using Northern Spy stems of various ages, all taken from one main branch, shows that velocity of flow is greatest in old stems and least in young ones. The time required for potassium ferro-cyanide to flow through 10-cm. segments was: In a 9-yr. stem, 237 sec.; in three 8-yr. stems, average 253 sec.; in three 7-yr. stems av. 279 sec.; and in three 3-yr. stems, av. 755 sec.

Relation Between Vessel Diameter and Rate of Flow

To determine whether or not differences in the average diameter of vessels of a stem and its branches might account, in part, for the difference in the rate of flow, the measurements of vessel diameters and determinations on rate of flow recorded in Table II were made. It is seen that the rate of flow is in the same order as the average vessel diameter, i.e., the stem, which has the largest vessels, has the highest rate, and that branch which has the smallest vessels has the lowest rate.

Because of the difficulty of determining accurately its cross-sectional area, the heartwood and some of the sapwood of the stem were removed by boring with a bit into one end for a few centimeters. The hole was filled with wax. All of the xylem remaining could be fairly assumed to be active conducting wood.

Ewart (2) has shown that the rate of flow of water through stems of several species is considerably less than would be expected from the rate calculated by Poiseuille's formula for rate of flow of liquids in small tubes. (3) The flow of water in smooth cylindrical tubes

of diameters comparable to those found in wood vessels is directly proportional to the fourth power of the diameter and inversely proportional to the length.

TABLE II.—RELATION BETWEEN VESSEL DIAMETER AND RATE OF FLOW IN STEM AND BRANCHES

1	2	3	4	5	6	7
Series C	Age Years	Area in Cross Section Branch, cm^2	Area in Cross Section Sapwood, cm^2	Number of Vessels Measured	Av. Diam. of Vessels mm.	Rate cc. per hour per cm^2 Sapwood
Stem...	10	9.3200	4.410	187	.0376	444.44
Branch	2	0.2209	0.204	77	.0223	161.60
Branch	1	0.0665	0.050	64	.0240	208.83
Branch	1	0.0510	0.034	77	.0200	139.94

In considering the relation between the rate of flow and the diameter of vessels, it is more instructive to compare the rate of flow in vessels of large diameter to that in vessels of small diameter than to compare the rate of flow in wood vessels to that in glass tubes.

The rate of flow in six one-year shoots, differing greatly in average vessel diameter, shows that the rate of flow is approximately proportional to the fourth power of the average vessel diameter. (Table III, columns 18 and 19.)

TABLE III.—RELATION BETWEEN VESSEL DIAMETER AND RATE OF FLOW IN ONE YEAR SHOOTS

1	2	3	4	5	6	7	8
Stem	Area Stem sq. cm.	Area Xylem sq. cm.	Total Water Carried in 1 hr. (cc.)	cc. per Hour per sq. cm. of Xylem	% Xylem Occupied by Lumen	Area Xylem Occupied by Lumen sq.cm.	cc. per Hour per sq. cm. of Lumen
A	1.343	1.3148	937.0	712.65	20.5	0.269	3483.3
B	0.545	0.5259	433.0	823.35	28.0	0.1474	2937.6
C	0.250	0.2285	89.5	391.68	19.1	0.0437	2048.0
D	0.138	0.1146	57.0	500.00	18.5	0.0212	2682.3
E	0.086	0.0686	20.8	303.20	18.7	0.0128	1625.0
F	0.037	0.0258	5.0	193.79	18.8	0.0048	1041.7

9	10	11	12	13	14	15
Stem	Av. Area Vessels sq. cm.	No. of Vessels in Shoot	Rate cc. per Hour per 1000 Vessels	Av. Diameter of Vessels mm.	Dif. Between Av. Diam. Stem A & B, B & C, etc.	Diff. / P.E.
A	1.586×10^{-5}	16060	55.25	$0.0450 \pm .00084$		
B	1.164×10^{-5}	12663	34.19	$0.0385 \pm .00087$	$0.0065 \pm .00121$	5.38
C	6.514×10^{-6}	6708	13.34	$0.0288 \pm .00010$	$0.0097 \pm .00088$	11.00
D	5.772×10^{-6}	3681	15.48	$0.0271 \pm .00068$	$0.0017 \pm .00068$	2.47
E	4.695×10^{-6}	2726	7.51	$0.0244 \pm .00070$	$0.0027 \pm .00097$	2.73
F	3.126×10^{-6}	1535	3.25	$0.0199 \pm .00055$	$0.0045 \pm .00089$	5.00

16	17	18	19
Stem	4th Power Vessel Diam.	Ratio (Diam.)^4 : (Diam.)^4	Ratio Rate per Vessel : Rate per Vessel
A	4.10×10^{-6}		
B	2.19×10^{-6}	A:B = 1.86:1	A:B = 1.60:1
C	6.88×10^{-7}	A:C = 5.94:1	A:C = 4.15:1
D	[illegible]0x10^{-7}	A:D = 7.50:1	A:D = 3.56:1
E	3.57×10^{-7}	A:E = 11.50:1	A:E = 7.35:1
F	1.58×10^{-7}	A:F = 25.80:1	A:F = 17.00:1

Incidentally, the rate of flow per square centimeter of sapwood may be less in a stem with relatively large vessels and relatively low percentage of lumen than in one with relatively small vessels and a relatively high percentage of lumen (A and B, columns 5 and 6).

In the experiments recorded in Table III, 15-cm. segments of one-year shoots were used. Transverse sections were made and the area of xylem of each was determined by projecting upon a screen an image enlarged 135 times, tracing upon paper, and measuring with a planimeter. The percentage of the xylem occupied by lumina in each section was determined in similar manner. An image of the section was projected upon a screen and large sheets of paper were placed so that the whole sheet would be covered by a portion of the image. The outlines of the vessels were traced and measured with a planimeter. From the area of the sheet of paper and the area of the vessels traced upon it, the percentage of xylem occupied by lumina was determined. The total area of lumen was calculated from the area of the xylem and the percentage of xylem occupied by lumina. The average diameter of vessels was determined by measurements taken with an ocular micrometer. The number of vessels in each shoot was calculated from the average diameter of vessels and the area of lumen. The rate per vessel per hour was obtained from the number of vessels and the volume of water conducted. The difference between the average diameter of vessels in branches A and B, B and C, etc., and the differences divided by their respective probable errors are also given in Table III.

Relation Between Length of Stem and Rate of Flow

The rate of flow in segments of stems is not exactly in inverse proportion to the length of the branch as would be expected from Poiseuille's law. In the case of long segments, reducing the length to one-half, more than doubles the flow; and, for short segments, reducing the length to one-half, does not quite double the flow (Table IV). There is some intermediate point at which the flow will be just doubled by reducing the length of the branch to one-half (Branch 42.) The determinations recorded in Table IV are representative of similar ones for 114 branch segments.

The rates of flow for two branches, and for halves, quarters, etc., of these branches are given in Table IV. The letters and figures in parentheses indicate whether the segment is the basal or apical half of the branch. The ratios are obtained by dividing the average rate of flow of the halves or the quarters by the rate of the whole branch. The ratios express the proportion to which the rate is increased by reducing the branch to one-half, or to one-fourth of its original length.

Just what the correct explanation for the peculiar relation between length and flow in these branches may be is not known, but it is probably due to structural peculiarities. The branch is not simply a bundle of straight tubes of uniform bore. The vessels are larger and more numerous at the basal end than at the apical end of the branch. The basal half conducts a larger volume than expected

TABLE IV—RELATION BETWEEN LENGTH OF STEM AND RATE OF FLOW

Stem Number	Length cm.	Diam. Base cm.	Age Branch Years	Flow per hr. (cc.)	Ratio—cc. Carried Whole : Half Stem	Ratio—cc. Carried Whole : Quarter Stem
75	130.0	1.35	4 & 5	85.0	1:2.41	1:5.25
76 (B 75)	65.0	1.35	4 & 5	252.0	1:2.12	1:4.07
77 (A 75)	65.0	1.35	4	158.6	1:2.24	
78 (B 76)	32.5	1.8	5	590.0	1:1.95	
79 (A 76)	32.5	1.55	4	480.0	1:1.91	
80 (B 77)	32.5	1.35	4	404.0		
81 (A 77)	32.5	1.25	4	314.0		
82 (B 78)	15.2	1.8	5	1200.0		
83 (A 78)	16.8	1.8	5	1062.0		
84 (B 79)	16.5	1.55	4	948.0		
85 (A 79)	16.5	1.4	4	894.0		
37	100.0	1.2	4	50.0	1:2.34	1:4.77
42 (B 37)	50.0	1.2		137.0	1:2.00	
43 (A 37)	50.0	1.1		97.0	1:2.14	
44 (B 42)	25.0	1.2		290.0	1:1.94	1:3.42
45 (A 42)	25.0	1.1		260.0	1:1.96	
46 (B 43)	25.0	1.1		230.0		
47 (A 43)	25.0	1.0		185.0		
49 (B 44)	12.5	1.2		560.0	1:1.75	
50 (A 44)	12.5	1.15		570.0	1:1.88	
51 (B 45)	12.5	1.1		515.0		
52 (A 45)	11.5	1.1		520.0		
53 (B 49)	6.1	1.2		1057.0		
54 (A 49)	6.2	1.2		835.0		
55 (B 50)	6.2	1.15		975.0		
56 (A 50)	5.5	1.15		1117.0		

A Apical half of stem.
B Basal half of stem.

and the apical half less than expected. When the branch is cut in two, probably more vessels become active conductors because vessels must end near the cambial region all along the stem, thus causing a progressive reduction in number of vessels from base to apex. This, it seems, would cause the flow to be greater in the basal half than expected. But this does not explain why the volume for short segments is less than expected. It may be that in the case of very short segments the velocity becomes great enough to cause turbulent flow. The velocities attained would not cause turbulence in smooth, straight tubes, but there are irregularities in vessels which would cause turbulent flow at lower velocities than if the vessels were smooth, straight cylinders of uniform bore. In the case of turbulent flow, the resistance is not directly proportional to speed but is raised to some power of the speed. Corrections for the end effects (not taken into consideration in these experiments) also might be great enough to be of some significance. That is, the apparent pressure is greater than the real pressure because of the energy required to move the water to the entrance of the vessel and that used up in causing continued motion of the stream after leaving the other end of the vessel. Probably if the proper corrections for decreasing diameter and number of vessels could be made, at low pressures, the rate of flow in branch segments would be found to be inversely proportional to the length of the segment.

Discussion

Obviously all the factors affecting the rate of flow of sap in trees are not easily determined. In the lower regions of the tree, the xylem is more efficient per unit area of cross-section than in the upper regions. In the lower, as compared to upper regions of the tree, the vessels are larger and probably have greater lengths of fairly uniform diameter uninterrupted by the possible constrictions which may exist in the region where the vessels laid down in different years connect. On the other hand, the relatively large cross-sectional area of the xylem at high levels may largely or entirely compensate for the relatively low efficiency per unit area in cross-section. It seems, therefore, that in regions at different levels of the tree there must be a nice balance between the capacities for conduction of water.

Pruning must disturb this balance. Heading-back would cause a reduction in the resistance to flow at least proportional to the reduction in length, since, in heading-back, the least efficient conducting wood is removed. Pruning, usually resulting in an invigoration of the remaining parts, would cause an increase in diameter of the vessels laid down in the invigorated region. The combined effect of increased vessel diameter and reduced length of stem after pruning must result in a much improved water supply to the remaining leaves. In situations where the water supply is a limiting factor, or in the case of mature trees, pruning, by increasing the water supply, may increase the efficiency of the remaining leaves sufficiently to more than compensate for the reduction in leaf area. It is con-

TABLE IV—RELATION BETWEEN LENGTH OF STEM AND RATE OF FLOW

Stem Number	Length cm.	Diam. Base cm.	Age Branch Years	Flow per hr. (cc.)	Ratio—cc. Carried Whole : Half Stem	Ratio—cc. Carried Whole : Quarter Stem
75	130.0	1.35	4 & 5	85.0	1:2.41	1:5.25
76 (B 75)	65.0	1.35	4 & 5	252.0	1:2.12	1:4.07
77 (A 75)	65.0	1.35	4	158.6	1:2.24	
78 (B 76)	32.5	1.8	5	590.0	1:1.95	
79 (A 76)	32.5	1.55	4	480.0	1:1.91	
80 (B 77)	32.5	1.35	4	404.0		
81 (A 77)	32.5	1.25	4	314.0		
82 (B 78)	15.2	1.8	5	1200.0		
83 (A 78)	16.8	1.8	5	1062.0		
84 (B 79)	16.5	1.55	4	948.0		
85 (A 79)	16.5	1.4	4	894.0		
37	100.0	1.2	4	50.0	1:2.34	1:4.77
42 (B 37)	50.0	1.2		137.0	1:2.00	
43 (A 37)	50.0	1.1		97.0	1:2.14	
44 (B 42)	25.0	1.2		290.0	1:1.94	1:3.42
45 (A 42)	25.0	1.1		260.0	1:1.96	
46 (B 43)	25.0	1.1		230.0		
47 (A 43)	25.0	1.0		185.0		
49 (B 44)	12.5	1.2		560.0	1:1.75	
50 (A 44)	12.5	1.15		570.0	1:1.88	
51 (B 45)	12.5	1.1		515.0		
52 (A 45)	11.5	1.1		520.0		
53 (B 49)	6.1	1.2		1057.0		
54 (A 49)	6.2	1.2		835.0		
55 (B 50)	6.2	1.15		975.0		
56 (A 50)	5.5	1.15		1117.0		

A Apical half of stem.
B Basal half of stem.

FIG. 1. Partridge Damage.

must reimburse the owner. Funds received from hunting licenses and similar sources are used for this purpose. The application of this rather just provision has led to a great deal of controversy between orchardists and sportsmen as to the seriousness and extent of the damage to apple trees when budded by partridges.

There is an immediate loss of a part of the fruit buds for the coming season. Since, as has been noted, the birds tend to leave the youngest spurs and since it has been shown by Tucker and Potter (5) that with the Baldwin variety young spurs are generally less productive than older ones, the buds taken are the ones among which there is the largest proportion of flowers. A contributing factor in this situation is the preference of the birds for the largest and most plump buds, leaving, if any are left, the small spurs which are continuously nonfruitful. On the other hand, Heinicke (4) has observed that pruning in the dormant season which reduces the number of buds and increases the water supply to those remaining, has a tendency to increase the set. Similarly, one might expect that killing of some of the spurs by budding would cause a larger proportion of those remaining to develop into apples than if the trees had not been budded. Counts of a number of spurs on some rather heavily budded Wealthy trees have indicated that such an increase in set, amounting in one instance to about 16 per cent, does actually occur. Considering then that the buds in general are taken from the most productive spurs but that those remaining tend to set a slightly higher proportion of fruit, an estimate that the percentage loss of crop is about equivalent to the percentage loss of spurs, cannot be far wrong.

The amount of the immediate loss of the crop would be affected if the budding produced any appreciable effect on the size of the fruits. In fact, some persons have been inclined to feel that the budding is similar to the practice of thinning and that therefore the loss should be minimized.

Haller and Magness (3) have called attention to the fact that the fruit of the apple, aside from its water content, consists almost wholly of carbohydrate materials the only source of which is photosynthesis in the leaves. The evidence presented by these investigators as to the minimum number of leaves necessary for full development of the fruits in several apple varieties makes it certain that the chief value of the practice of thinning lies in increasing the number of leaves available to each fruit as a source of food supply. Obviously any process which removes *both leaves and fruit* does not accomplish this purpose. On the other hand, the water supply in the case of trees not heavily loaded may limit development of the fruits and since loss of water by transpiration is reduced when part of the foliage is removed, the amount available to each apple would be increased in budded trees. A few instances are on record in which the size of fruit was increased due to budding. It seems most logical to attribute this to the increase in water supply and to a lesser degree to the fact that as mentioned before, the spurs left at the tips of branches produce a smaller percentage of flowers than the average for the tree, and in consequence the budding results in a slightly increased leaf area per fruit.

On the other hand, as will be seen later, budding over a series of years may so reduce the vitality and size of leaves as to materially decrease the average size of fruits. In general, however, the influence of the budding during any winter on size of fruits for the succeeding year is not material and need not be considered in estimating the *immediate* loss of fruit.

Spurs which have been budded in the manner described are generally killed outright. Sometimes a weak lateral bud, on the lower part of the spur, may throw out a few relatively small leaves. Such growths, when they occur, are usually weak and only rarely does the spur produce fruit again. Personally, the writer has observed only one spur which clearly had been budded and which had sent out a sufficiently strong lateral to blossom. He has been told of one orchard in which a considerable number of spurs have thus regained normal vigor. For all practical purposes, however, the recovery of the spurs after budding is negligible. It is certain, therefore, that a permanent reduction in the bearing capacity of the tree has resulted, unless it can be shown either that the production of new spurs by the tree is accelerated or that the reduced number of spurs remaining on the tree are made more efficient, in producing blossoms and fruits. This leads to a discussion of the probable effect of budding on the nutrition and growth of the tree.

Budding, like pruning, reduces the leaf area and the number of growing points without, for the time being at least, reducing the absorbing surface of the root. Hence a change in the nutritional balance or carbohydrate nitrogen ratio of the tree may be anticipated which would under average field conditions stimulate top growth. Work, such as that of Gourley and Shunk (2), has shown conclusively that the supply of the most important single element, nitrogen, is exceedingly low in orchards which are in sod and which are not given special fertilizer treatment. Such trees then, as stand in sod and old pastures, tend to have a relative over-supply of carbohydrate foods synthesized by the leaves as compared to the elements derived from the soil, particularly nitrogen. Budding, like pruning, under these conditions whould be expected to result in a decided stimulus to growth and would probably result in more efficient blossom production by the spurs. On the other hand, trees in cultivated orchards or sod orchards which are suitably mulched and fertilized with ample amounts of available nitrogenous fertilizer, nutritional conditions, especially after the necessary and usual pruning has been done, will be about the optimum for best growth and production. When the foliage of such a tree is removed by budding, less stimulus toward growth is to be expected and no increase in fruitfulness of the spurs.

Such observations as have been made appear to substantiate these expectations. Under the average orchard conditions the rate of increase of new spurs may be slightly accelerated after budding, but that acceleration is not sufficient to replace the loss for a number of seasons. In 1923 and 1924 counts were made of spurs killed and of new spurs produced in two blocks of Wealthy trees situated on the Gould Farm at Contoocook, N. H. Of course, all of the trees in any

given block are attacked by the birds and it is necessary to check their performance against a block located at some distance. Comparisons are subject to the usual hazards of a single plot experiment. Nevertheless, it is of interest to note that unbudded Wealthy trees, about twelve years of age, produced on the average during the season of 1923, approximately 800 new spurs each. Trees rather severely budded during the previous winter, which were one year younger, produced on the average about 1200 new spurs each. The budded trees had lost 1200 to 1400 spurs each through the inroads of the birds. They had therefore, in the first season after budding, some 1200 less spurs per tree on which to bear fruit. In the second season they were equipped with 800 less spurs per tree. Owing to the press of other experimental work these counts were not continued in succeeding years but it may be said that after three to four seasons the budded Wealthy trees, which in this case suffered from no more attacks by the birds, appeared to have returned to normal. It is probable, however, that they are still somewhat smaller than they would have been had they not lost the 1200 spurs each during the winter of 1922–23. The trees in this instance were in sod in an orchard which is only fairly well fertilized with nitrogen. Mr. Gould believes firmly in the use of a complete fertilizer and the applications which he makes do not contain as much actual nitrogen per tree as is generally believed to be necessary for most vigorous growth and production in sod mulch orchards in New Hampshire.

Counts were made in this same orchard to determine the proportion of blossoming to non-blossoming spurs, both in 1923 and 1924. The results indicate no appreciable difference in proportion of flowers produced on the spurs of budded and non-budded trees. In other words, no grounds whatever are found for assuming that the smaller number of spurs on the budded trees are more productive because of the budding. It appears rather that a loss of crop would result for a number of years in proportion to the reduced number of spurs on the trees.

The change in nutritional balance of the tree would be expected to be in proportion to the number of spurs removed, and a light budding would be followed by a relatively small increase in rate of production of new spurs. On the other hand, in the case of very heavy budding such as to cause a loss of three-fourths of the foliage, the nutrition would probably be so thrown out of balance as to reduce rather than increase the rate of growth.

No discussion of this problem would be complete without a consideration of the ultimate, in addition to the immediate, effect on growth of the tree which may be expected to result from a loss of foliage such as is brought about by budding. Pruning experiments such as those of Chandler (1) have probably made it clear that such reduction of the foliage even where it produces a stimulus to shoot growth, reduces root growth materially. It is evident, then, that budding, like pruning, must ultimately, through a reduction of the root system, limit the supply of water and soil elements. Con-

tinued budding would accordingly be expected to reduce the vitality of the trees and that such is the case is evident from observations in orchards.

Certain experiments on the use of nitrogen fertilizers are conducted by this station in the Rockwood orchards at Temple, N. H. This orchard is bordered by woodland on one side and here the trees have been rather seriously and continuously budded for a period of eight to ten years. In selecting pairs of trees for the fertilizer experiment an effort was made, of course, to keep away from those most seriously affected by budding, but of necessity a few trees were used in the side of the orchard nearest the woodland. Naturally those which showed least effects of the budding were chosen. During the three years since the experiment was started these trees have steadily declined in vigor and records taken incidental to the work with fertilizers demonstrate that these trees are now much below the others in growth and production. The average production per tree in 1928, of seven trees in this portion of the orchard, was 448 pounds of apples, the average diameter of which was 2.20 inches. The average production of the trees farther from the woodland, which are also budded but not to such a serious extent, was 572 pounds each, of apples 2.34 inches in diameter. While only average size of fruit was determined in this instance, data taken in thinning experiment in a number of orchards in New Hampshire in 1928, enable us to calculate the variation in size which would be likely to exist and to estimate that the yield of marketable fruit 2¼ inches in size or larger, was reduced from 378 pounds per tree to 197 pounds by the budding. This is a loss of more than a barrel of marketable fruit per tree. Some counts of dead and live spurs indicate that the total number of buds removed from the trees seriously affected is only about 50 per cent. Measurements of typical branches indicate, however, that at present new growth and production of new spurs on these trees is proceeding only about one-half as rapidly as upon the trees which are farther from the woodland.

Here, too, the possibility must be considered of the low vigor in this section of the orchard being due to some local factor other than the budding. Mr. Rockwood and his father testify that up to ten years ago, before budding became prevalent, the trees on the side of the orchard nearest the woodland were larger and more productive than in the other side of the field. This statement is undoubtedly true and makes it appear unlikely that excess water or low soil fertility may be responsible for the differences observed. It would be recognized, however, that in case there was rather too much water in that section of the orchard, a budded tree would most certainly suffer more than one not budded, owing to the reduction in the foliage and consequent reduction in the amount of water which the tree would remove from the soil and use in transpiration.

In one respect budding is distinctly different from pruning, namely, that it removes leaves without removing branches. The branches left are of large diameter for the foliage they carry, and some question may be raised as to whether under these conditions an adequate in-

crement of new conductive tissue would be laid down. Often the reduction in vigor seems greater than one would expect, merely from limitation of the carbohydrate supply. The leaves on the spurs which remain are relatively small and non-vigorous. This in itself suggests that other factors such as the possible reduction in the amount of the efficient conductive tissue may be contributing to the ultimate result.

Weak trees with scant foliage are also especially susceptible to winter injury and canker, two troubles which are likely to be prevalent in New Hampshire Baldwin orchards. Beyond question budding increases the prevalence of these troubles.

LITERATURE CITED

1. CHANDLER, W. H. Results of some experiments in pruning fruit trees. N. Y. (Cornell) Agr. Expt. Sta. Bul. 415, 5–74. 1923.
2. GOURLEY, J. H., and SHUNK, V. D. Notes on the presence of nitrates in orchard soils. N. H. Agr. Expt. Sta. Tech. Bul. 11, 3–31. 1916.
3. HALLER, M. H., and MAGNESS, J. R. The relation of leaf area to the growth and composition of apples. Proc. Amer. Soc. Hort. Sci., 22:189–196. 1925.
4. HEINICKE, A. J. Factors influencing the abscission of flowers and partially developed fruits of the apple. (*Pyrus malus* L.) N. Y. (Cornell) Agr. Expt. Sta. Bul. 393, 1–114. 1917.
5. TUCKER, L. R., and POTTER, G. F. Characteristics of growth and fruiting in the Baldwin apple. Proc. Amer. Soc. Hort. Sci., 25:000–000. 1928.

Effect of Dormant and Delayed Dormant Application of Oil Sprays on Apple Trees

By F. L. OVERLEY, AND ANTHONY SPULER, *State College of Washington, Pullman, Wash.*

OIL sprays have been applied on dormant trees for the control of such insects as San Jose scale, orchard leaf roller and oyster shell scale for a number of years and are now generally regarded as an effective treatment for insects. They have been applied at strengths ranging from 4 per cent actual oil for San Jose scale to 8 per cent actual oil for the orchard leaf roller. Aphis infestations which have been more or less severe in recent years have led many growers to delay the oil sprays until the green and rosy aphis were hatched. This was done because the oil sprays failed to kill an appreciable number of the aphis eggs. This delay in application has resulted in more or less injury.

In order to determine what factors were instrumental in bringing this about, experiments were conducted in the Wenatchee District of Washington to study: (1) The relation of minimum temperatures to oil injury; (2) the relation of toxicity of oil sprays to plants in dormant and semi-dormant stages; (3) the value of oil refinement in prevention of injury; and (4) the effect of early application on San Jose Scale control.

The tests were started January 19 and continued every two weeks until the regular commercial spray which was applied March 28: A standard oil with a viscosity of 100 and unsulphonated residue of

65–70 was used in a 4 per cent actual oil solution in all tests up to the last. On the last spray the same type oil was used but the strength was reduced to 3.3 per cent. At the time the commercial spray was applied several different oils were used for comparison. A case in-lime spreader was used as an emulsifying agent in oil No. 5 and, oil No. 2, and Shell Brown Neutral. The Stayman was the main variety used in the complete series of tests. Other varieties as Jonathan, Delicious, Rome and Winesap were sprayed with the different oils at the time of the regular commercial spray, March 28.

In the series of tests starting January 19, the oil spray was applied to one large limb of each tree on five different trees for each test except the last spray. A check limb was also left unsprayed in each tree. In the last test, March 28, whole trees were sprayed. A small bucket sprayer was used to apply the oil spray in the tests January 19 to March 15 inclusive. The commercial spray was applied on March 28 with the stationary sprayer at 400 pounds pressure.

The flower and leaf buds on all early spraying tests including March 15 appeared to be equal to the checks. On the trees sprayed March 28, both the flower and leaf buds were not only delayed in starting but appeared to be weaker. A large number of fruit buds were killed outright and many of the leaf buds on the previous season's growth failed to start growth throughout the whole season.

The buds were absolutely dormant when the sprays from January 19 to March 15 inclusive, were applied, but the bud scales had separated and green was showing when the spray of March 28 was applied. Green aphis had been hatching for approximately one week at this time. Temperature records were kept throughout the tests as follows: Sprayed Jan. 19, weather cloudy, clouds low; spray froze on trees at time of spraying, forming icicles. Temperature at time of spraying 30 degrees F. Min. temp, Jan. 19–Feb. 3 varied from 32 to 16 degrees F. Sprayed Feb. 3, weather cloudy, temp. 40 degrees F. at time of spraying. Min. temp. Feb. 3–Feb. 15 varied from 32.5 to 21 degrees F. Sprayed Feb. 15, weather cloudy, temp. near freezing at time of application, min. for day 26.5 degrees. Min. temp Feb. 15–Mar. 2 varied from 32 to 14.5 degrees F. Sprayed Mar. 2, weather partly cloudy, freezing at time of application, min. for day 16.5 degrees. Min. temp. Mar. 2–Mar. 15 varied from 35 to 16.5 degrees F. Sprayed Mar. 15, weather partly cloudy, temp. 52 degrees F. at time of application, min. temp. for day 34 degrees F. Min. temp. Mar. 15 to Mar. 25 varied from 45 to 27 degrees F. Sprayed Mar. 28, weather sunny, temp. 60 degrees at time of application, min. temp. for day 37 degrees F. Min. temp. Mar. 28–April 10 varied from 37 to 22 degrees F.

Counts of the number of buds that produced flowers per cluster are shown in Table I. The averages of these counts per plot show very little difference in the first five sprays compared with the check, while the average of the sixth spray shows a marked reduction.

TABLE I—AVERAGE NUMBER OF FLOWER BUDS AT BLOSSOM TIME FOLLOWING DIFFERENT DATES OF DORMANT AND DELAYED DORMANT SPRAY ON STAYMAN

Check	Date Sprayed					
	Jan. 19	Feb. 3	Feb. 16	March 1	March 15	March 24
3.06	3.26	3.60	3.54	3.32	3.30	2.12
3.03	3.01	3.26	3.17	2.29	3.72	.32
3.55	3.66	3.48	3.21	4.08	3.40	.92
3.54	3.70	3.53	3.63	3.80	3.98	1.29
4.04	3.64	3.63	3.68	3.88	3.37	——
Ave.						
3.72	3.33	3.8[illegible]	3.74	3.79	3.92	1.16

As shown in Table II, the percentage of injury to fruit buds was very high following the spray of March 28. The percent of injury for all previous sprays was about the same as the check. The results of the different sprays up to March 28 were paired according to tree, since each tree in the test had one check limb and a limb for each of the five sprays. The March 28 spray was applied on different but adjoining trees. A representative limb of the latter tests was paired with the checks and the results of all tests figured according to Student's Biometric Method. The results show that the odds are not significant on all the early sprays as compared to the check. The results of the last spray with odds 431 to 1 show outstanding fruit bud injury.

TABLE II—PERCENTAGE OF FRUIT BUDS INJURED FROM DORMANT OR DELAYED DORMANT SPRAY ON STAYMAN

Check	Date Sprayed					
	Jan. 19	Feb. 3	Feb. 16	March 1	March 15	March 28
29.1	34.7	27.8	29.0	29.0	33.0	58.0
37.7	40.0	34.6	36.5	43.0	25.6	93.6
29.0	27.4	27.7	35.8	18.4	32.0	81.3
28.9	25.5	28.5	28.0	23.8	20.4	73.8
21.6	27.7	25.4	25.7	25.9	27.7	
Ave.						
29.3	31.1	28.8	31.0	28.0	27.7	74.7
Odds	8.2:1	1:5.9	5.4:1	1:1.6	1:5.4	434:1

In the study on the set of fruit following the different dates of spraying the average percentages and odds show very little difference for the first five sprays as compared with the check. As shown in Table III, the tree sprayed March 15 shows a high percentage of fruit set in three out of six branches including the check. For this reason the four trees sprayed March 28 were compared with only the first four check trees.

The average set of fruit on the first four check limbs is 4.42 as compared with 1.08 set of fruit on trees sprayed March 28. Thus figured the odds are 999 to 1 in favor of the check. In other words under similar conditions for other trees or other years lower set of fruit would occur on trees sprayed with the same oil spray at the same developed condition of the fruit buds.

TABLE III—PERCENTAGE SET OF FRUIT FOLLOWING DIFFERENT DATES OF DORMANT AND DELAYED DORMANT SPRAYING ON STAYMAN

Check	Date Sprayed					
	Jan. 19	Feb. 3	Feb. 16	March 1	March 15	March 28
6.81	4.99	3.75	5.63	8.74	4.13	2.71
4.02	5.04	3.62	7.26	1.29	4.12	0.00
2.46	3.64	7.93	4.99	3.19	5.37	0.01
4.41	3.42	6.12	3.06	8.58	3.18	1.57
11.28	13.28	4.85	4.71	7.28	19.66	
Ave.						
5.79	6.07	5.21	5.13	5.81	7.29	1.08
Odds	1:1.6	1.2:1	1.66:1	1:1	1:2.72	999:1

Comparisons were made by applying the following oils on different varieties at 3.3 strength actual oil on March 27–28–29 with all fruit buds showing green or what might be called a delayed dormant stage: (1) Shell Brown Neutral, viscosity 107 unsulphonated residue 50; (2) Standard No. 5, viscosity 100–110, unsulphonated residue 70; (3) Red Engine, viscosity 220, unsulphonated residue 50; (4) Sherwin-Williams free emulsion, viscosity 140, unsulphonated residue 68; (5) Associated Avon, viscosity 126, unsulphonated residue 54; (6) Ortho Kleenup, viscosity 100–112, unsulphonated residue 72; (7) XXX Dormant, viscosity 70, unsulphonated residue 84.

The counts were made on flower buds, percentage of fruit buds injured, and the percentage set of fruit after spraying with the oils listed above on Delicious, Rome, Jonathan and Winesap. The results checked very closely to the results reported on Stayman. These results can be verified by many growers in the Wenatchee District.

The time of application seems to have little effect upon the efficiency of oil sprays on San Jose scale control as shown in Table IV.

TABLE IV

Treatment	Date Sprayed	Date Examined	Strength Oil in Per cent	San Jose Scale			
				Total Control	No. Dead	No. Alive	Per cent Dead
Check	——	Feb. 2	—	2360	240	2120	10.1
Oil No. 5	Feb. 2	Apr. 1	4.0	2800	2800	0	100.0
Check	——	March 28	—	1315	450	865	35.0
Oil No. 5	March 28	May 1	3.3	2261	2261	0	100.0

Although the earlier spray was of 4 per cent concentration as compared to 3.3 per cent concentration of the later spray, the amount of actual oil applied on the trees was probably the same since the earlier spray was applied with a bucket pump, which did not permit such heavy spraying as was done with the power outfit.

Measuring the Efficiency of the Spray Program

By W. H. Thies, *Massachusetts Agricultural College, Amherst, Mass.*

It is the purpose of this paper to suggest a simple workable method of checking over the crop at harvest time for the purpose of determining the degree of success or failure of the spray program. In Massachusetts 47 orchards were checked last fall by the method described below.

Obviously it is impossible to examine every apple in a given block, but if a lesson is taken from the estimator of hail damage a representative sample of fruit may be easily secured. In any given block of trees it is not difficult to select five trees which will represent the orchard as a whole from the standpoint of variation in size in location, as well as in the amount of injury due to various apple insects and diseases. Then from each of these five trees a portion of the fruit is harvested in such a way as to include apples from both sides, top, bottom, and inside. In other words, a strip is picked clean from one side of the tree to the center, and through to the other side. To include a fair proportion of the outer branches, this strip should be somewhat wider on the outside of the tree than the inside. The writer does not claim any originality in this method of selecting samples; it is almost exactly the same as is used in checking the fruit for an estimate of damage due to hail. In general, it is believed that about a bushel of fruit should be harvested from each tree, making a total sample of five bushels from the orchard.

With this sample of "orchard run" fruit on hand, the crew of three men is ready to record results. A battery of tallies of the type in common use for making counts is necessary, with one tally for each type of blemish to be observed as well as one for those free from defects, and if the variety is one subject to russet, an extra tally is needed. Each apple is then examined by one of the members of the crew, who must be familiar with the injuries due to various apple pests, and the condition of each fruit is announced to the person operating the tallies. A crew of three men can quite readily look over a sample of five bushels of average apples in one hour, and if one hour's time is allowed for selecting the sample, it is quite obvious that the time element is not serious.

At this point it may be well to explain that the method just described results in a fund of information of greater value than an examination of culls alone. As may readily be seen, it provides data for calculating the percentages of clean and of russeted fruit in an orchard as well as the percentage of fruit attacked by any of the common pests. In brief, it gives a picture of the crop as a whole, since the sample selected was a cross section of the entire crop.

All of the data including the spray schedule of the grower is tabulated on a single sheet as shown in the accompanying form. This makes it possible to correlate the pests actually in evidence in the harvested crop with the spray program carried out earlier in the sea-

son, and if the percentage of one particular blemish appears higher than it should be, a clue to the situation may be found in the omission of one or more of the critical sprays.

(FORM USED IN TABULATING ORCHARD DATA)

Orchard of. . . . .

Address. . . . .

Spray schedule. . . . .

Condition of Fruit	No. of Apples	Percentage
Clean.		
Russet.		
Scab.		
Sooty Fungus.		
Black Rot.		
Miscellaneous Diseases.		
Codling Moth.		
Plum Curculio.		
Apple Maggot.		
Red Bug.		
Leaf Roller.		
Miscellaneous Insects.		
Total.		
Duplicates.		

The data secured from the check up just described serves a double purpose. The grower himself has a chance to look at his results squarely, and to modify his program to fit existing conditions. Furthermore, the authorities responsible for formulating the spray schedule for a given section may use it to check previous recommendations, and if the survey is made in a sufficiently large number of widely separated orchards it permits them to modify the recommendations for a given pest in that part of the section where conditions are abnormal. A few examples will suffice to illustrate how the survey works out in actual practice.

One of the most outstanding observations in Massachusetts this year is that the russet on Baldwins which has been attributed so largely in years past to faulty spraying, is, in part at least, the result of unfavorable weather. In the 47 orchards checked this season, all but two of which were of the Baldwin variety, russet was found to be almost universal. Nineteen per cent of the fruit had sufficient russet to throw it out of the A grade. Of the 45 Baldwin orchards, five had received no spray at all, but even in these unsprayed orchards an amount of russet comparable to that in the sprayed orchards was evident. Also there was very little difference between the amount of russet in sprayed and dusted orchards this season. This, of course, does not disprove the theory that much of our russet in previous years has been due to errors in spraying, but the high humidity of the past season and to some extent low temperatures after the buds had opened must take part of the blame for russeting of fruit this year.

The average grower is likely to over-estimate the quality of his fruit. He is inclined to overlook minor defects and in many instances

fails to recognize some of his most serious troubles at all. For this reason he has greater need for an accurate measure of his spray efforts. His snap judgment is quite likely to be wrong. He thinks he is doing a good job because he wants to do a good job, and unless he can be shown that 10 or 20 per cent of his crop is actually being blemished by a pest such as curculio, he may feel that the injury is trivial. The following example shows how a grower unaccustomed to careful observation looks at his crop. A check had just been completed of Mr. Smith's crop of Baldwins, when he remarked that the fruit from certain trees which had received no spray at all was, in his opinion, in better condition than the fruit just checked. However, examination of the unsprayed crop showed that one apple in three had been attacked by codling moth, while the sprayed sample showed less than 1 per cent. Curculio was about five times as numerous and miscellaneous insects twice as prevalent. The owner's reason for believing that the unsprayed fruit was better was that it showed higher color, due to growing in sod, and the higher color had obscured his view of most of the blemishes.

The survey described above has brought to light another interesting fact. In eastern Massachusetts the plum curculio is not being controlled except in the most intensively sprayed orchards. In general the per cent of fruit blemished by this pest runs altogether too high. In western Massachusetts, however, it appears that the usual spray program holds this insect in check, while in the badly infested areas, orchard sanitation seems to be a necessary supplement to the spray program.

A careful study of representative samples of "orchard run" fruit is one of the most effective means of measuring the extent to which spray materials have served a useful purpose. The work will be continued next year when further effort will be made to perfect this "yardstick" of the Massachusetts spray program.

A Method of Modifying the Lime-Sulphur-Lead Arsenate Spray to Reduce Foliage Injury in the Apple

By W. C. Dutton, *Michigan State College, East Lansing, Mich.*

THE standard fungicide for the control of apple scab in Michigan, and in many other districts, is lime-sulphur. Ordinary or acid lead arsenate is usually used in combination with the lime-sulphur. The combination, if properly used, is effective in scab control but, unfortunately, foliage injury frequently follows its use. There are several types of injury that follow the use of lime-sulphur or lead arsenate alone or of the two combined and it is frequently very difficult to identify definitely the various forms of injury. It is probably true, however, for Michigan and for other districts with similar conditions, that the injurious effects arising from the combination of lime-sulphur and acid lead arsenate are more serious than the injuries that may follow the use of either one alone. This injury usually takes the form of brown spotting of the leaves which is followed by yellowing and premature leaf-fall.

Many substitutes for and modifications of lime-sulphur have been offered to eliminate or reduce the several injurious effects. Some of these have been much less injurious to foliage but have also been less effective in scab control. The use of certain of the modifications has resulted in improvement in some respects but the results have not been such that their general use could be advised. However, one modification of the lime-sulphur-lead arsenate spray that has been studied for the past four seasons gives promise of being very valuable where foliage injury is an important factor.

This modification consists simply of combining a small amount of ferrous sulphate with the lime-sulphur and lead arsenate. Amounts varying from one-half pound to three and one-half pounds for each gallon of lime-sulphur concentrate have been used. The results, however, indicate that one-half pound of ferrous sulphate for each gallon of lime-sulphur concentrate is probably the optimum amount when all factors are considered. The use of large amounts results in less foliage injury but the physical properties of the mixture are not good and the fungicidal value is probably lowered.

The method of mixing advised at present is to add the iron sulphate, previously dissolved, to the partly filled sprayer tank, then, with agitation, add the lead arsenate, and when the tank is nearly full, the lime-sulphur. The resulting mixture is black. The residue on the trees turns to a rust color after a few days.

The use of this mixture in the late summer usually results in some undesirable staining of the fruit and blotchy coloring because of the persistence of the residue. This is obviously undesirable but the difficulty can be overcome, in Michigan at least, by substituting a 2–2–100 Bordeaux (without ferrous sulphate) for the last spray. Foliage injury is not likely to occur and russeting of the fruit does not develop at this late period.

The improvement following the use of this procedure has been very marked and may be seen as somewhat lessened russeting of the fruit, remarkably better foliage, better and brighter color of fruit, and larger size of the fruit. The better color and larger size are undoubtedly the result of the improved condition of the foliage.

This procedure is not offered as a cure for all the troubles encountered in spraying practice, and improvement in the method of its use is undoubtedly possible. There are probably weak points. For example, it may be slightly less effective in scab control than the regular lime-sulphur-lead arsenate combination, and the full effect of the iron sulphate on the insecticidal efficiency of the lead arsenate has not been determined. The improvement in the condition of the foliage and fruit, however, has been so great that the adoption of this procedure seems advisable in Michigan, where foliage injury has been a serious factor.

Further Notes Regarding Peach Rust Control

By W. P. DURUZ, *University of California, Davis, California*

THE first report on the control of peach rust (*Tranzschelia punctata* Pers.) by means of spraying was given a year ago. This is a report of the second year's work. The investigation has been conducted along three lines: Survey of commercial spraying, field studies of the fungus, and intensive spraying experiments.

The fungus attacks the favored midsummer canning clingstone varieties such as Paloro, Peak, Hauss, Gaume, Johnson, Walton and Sims. The Tuscan and Phillips are not so readily susceptible. Freestone varieties may become infected especially if in the immediate vicinity of one of the above more susceptible sorts.

There are three places of infection, namely, on twig, leaf, and fruit, appearing usually in the order named. The fungus carries over the winter in the new twigs and sporulates early in the spring. Leaf infections appear as small yellow angular spots in early summer on primary leaves which are usually in close proximity to the bark pustule. With favorable climatic conditions the infection spreads to other leaves and to the young fruits. The fruit infection is the most important stage from an economic standpoint. Infected fruit becomes pitted with small, dark-green, hard areas which make the fruit unattractive and difficult to peel. Peaches with rust spots are rejected by commercial canneries.

SPRAYING SURVEY

On account of the nature of the fungus and on the basis of previous results with sprays it seemed advisable to make a strenuous effort to bring the disease under control by means of early fall application of lime sulfur. Growers were circularized and personally advised at farm bureau meetings and other gatherings. The recommendation was to spray with liquid lime-sulfur, 7 gallons (32 degrees B.) in 100

gallons of spray between October 15 and November 1. It should be mentioned that this date is somewhat earlier than is customary because most of the leaves are still on the trees and spraying is then more difficult and expensive. Nevertheless the great majority of growers followed the recommendations, some spraying even earlier than advised in order to cover large acreages in time.

A personal survey was conducted by the writer to secure first-hand information regarding the type of application in some 40 commercial orchards. A record sheet was kept for each orchard and visits were made later to tabulate results as regards spray injury and control. In addition to the personal survey several hundred report blanks were returned by growers who kept their own spray records.

The first noticeable result was that, contrary to the general idea, the earlier applications of lime-sulfur resulted in no spray injury whatsoever. Spraying, as early as October 4 did not cause even the leaves to drop, much less produce any twig "burning," whereas spraying after November 15th in a few orchards produced considerable "spray burn" to the twigs and long shoots. It was thought that either climatic or soil conditions or the growth of the trees may have been responsible for such differences in the amount of injury. More thorough studies on this point should be made.

The results as regards control of peach rust showed that not one of the orchards, which were sprayed according to recommendations, developed the disease, whereas several orchards that were not sprayed as recommended developed serious cases. These latter orchards were sprayed later than was advised, and, true to expectations, showed signs of leaf infection that were very alarming and might have resulted in serious loss had not summer preventive sprays or dusts been applied and had summer climatic conditions been more favorable for peach rust development.

Field Studies of the Peach Rust

In order to secure more exact information regarding the life history of the peach rust fungus, a number of twigs were selected and tagged. These were on unsprayed trees in several infected orchards. Current season twigs were chosen of such character as from previous observations seemed would become infected. Frequent examinations were made during autumn and winter, for evidence of bark pustules in these twigs. Some were found early in January. This evidence seemed to prove that infection was initiated by infection which took place the previous fall. This is important information which further emphasizes the necessity of fall spraying to prevent the infection of current season wood growth and thus eliminate dangerous sources of infection. Leaf infection in unsprayed trees developed during April, May and early June. In every case the primary infection could be traced to a bark pustule in the immediate vicinity of a leaf infection area.

Some information has been gathered which seems to show a direct correlation between summer rain and continued development of rust infection on leaves and on fruit. Weather bureau records for 1926

showed a total of 5 inches of rain in April and May. This was favorable for peach rust, and an epiphytotic occurred. The records for the season of 1927 showed a total of 3.48 inches in April, May and early June and this was accompanied by a great deal of rust in the leaves and fruit. In fact, it was quite evident that the 0.66 inches of rain on June 7, 1927 was responsible for all of the fruit infection that year.

During the summer of 1928 on the other hand, there was an absence of rain in the early summer months, almost none being recorded in late April, May, June, July or August. Likewise, there was an absence of continued rust development in the leaves and none whatever in the fruit. No fruit rust developed even in orchards where there was an early and severe primary leaf infection. Furthermore, these orchards were abundantly irrigated so that the humidity was relatively high and would have been favorable for some diseases.

It seems, therefore, that rain is necessary for the continued development of the summer stages of peach rust. That is, the leaves or fruit themselves must be wet for several hours in order to allow infection to take place.

Orchard Spraying Experiments

The orchard spraying experiments were designed to repeat and verify the results of the previous year and to test a number of additional factors. Five infected orchards in different localities were selected. About 500 trees were used in each orchard and these were divided into blocks of about 80 trees, to be sprayed at different times and with various materials. The sprays were standard materials such as liquid lime-sulfur, dry lime-sulfur, Bordeaux mixture, and miscible oils, used at varying dilutions. Unsprayed trees were left singly, and in groups throughout the respective blocks.

At frequent periods following the application of the sprays, observations were made to detect any differences as regards spray injury to the trees or in the development of peach rust. During the course of these observations it was evident, as would be expected, that the unsprayed trees were developing the disease very much more than the sprayed trees. Differences between the treated blocks of trees, however, were not noticeable to the casual observer. As stated previously, the disease in 1928 did not develop very much after early spring, due to the absence of rain. On close examination, however, significant differences could be determined. Therefore, all of the trees were carefully examined and scored for amount of leaf infection. The results in one orchard which is typical of all of them are given in Table I.

Discussion of Results

Referring to the data the following points will be noted:

1. All of the sprays applied in the early fall gave good control (blocks 2, 4, 5).
2. The late fall applications alone were not effective (block 3).
3. Two applications at certain times were more effective than one (block 6). This seems to have to do with killing successive crops of spores in the bark pustules.

TABLE I—PEACH RUST SPRAYING EXPERIMENTS—SUMMARY OF RESULTS, 1927–1928

Yuba Farms, Inc., Marysville, California.

Block No.	No. Sprays	Material	Time of Application	Date	Ave. No. Leaf Infections per Tree	Block Average
1	2	Liquid lime-sulfur	Spring	2–21–28		
		Liquid lime-sulfur	Early Summer	5–29–28	4.5	
	2	Liquid lime-sulfur (½ strength)	Ditto	Ditto	16.0	
	2	Liquid lime-sulfur and oil	Ditto	Ditto	12.0	
	2	Dry lime-sulfur	Ditto	Ditto	67.0	
	2	Bordeaux (home-made)	Ditto	Ditto	18.9	
	2	Bordeaux (commercial) and oil	Ditto	Ditto	25.5	26.9
		None	——	——	50.0	
		None	——	——	150.0	100.00
2	1	Liquid lime-sulfur	Early Fall	10–23–27	2.7	
	1	Liquid lime-sulfur (½ strength)	Ditto	Ditto	4.0	
	1	Liquid lime-sulfur and oil	Ditto	Ditto	1.0	
	1	Dry lime-sulfur	Ditto	Ditto	7.8	
	1	Bordeaux (home-made)	Ditto	Ditto	2.7	
	1	Bordeaux (commercial) and oil	Ditto	Ditto	15.6	5.6
		None	——	——	150.0	
		None	——	——	130.0	140.0
3	1	Liquid lime-sulfur	Late Fall	11–23–27	43.5	
	1	Liquid lime-sulfur (½ strength)	Ditto	Ditto	94.0	
	1	Liquid lime-sulfur and oil	Ditto	Ditto	85.0	
	1	Dry lime-sulfur	Ditto	Ditto	51.2	
	1	Bordeaux (home-made)	Ditto	Ditto	97.0	66.5
		None	——	——	50.0	
		None	——	——	80.0	65.0
4	2	Liquid lime-sulfur	Early fall	10–23–27		
		Liquid lime-sulfur	Late fall	11–23–27	2.6	
	2	Liquid lime-sulfur (½ strength)	Ditto	Ditto	3.3	
	2	Liquid lime-sulfur and oil	Ditto	Ditto	2.5	
	2	Dry lime-sulfur	Ditto	Ditto	1.3	
	2	Bordeaux (home-made)	Ditto	Ditto	5.2	
	2	Bordeaux (commerical) and oil	Ditto	Ditto	1.0	2.4
		None	——	——	110.0	
		None	——	——	40.0	75.0

TABLE I—*Continued*

Block No.	No. Sprays	Material	Time of Application	Date	Ave. No. Leaf Infections per Tree	Block Average
5	2	Liquid lime-sulfur	Early fall	10–23–27	8.0	
		Liquid lime-sulfur	Spring	2–20–28		
	2	Liquid lime-sulfur (½ strength)	Ditto	Ditto	5.1	
	2	Liquid lime-sulfur and oil	Ditto	Ditto	0.3	
	2	Dry lime-sulfur	Ditto	Ditto	4.9	
	2	Bordeaux (home-	Ditto	Ditto	3.0	
		made)	Ditto	Ditto	3.0	
	2	Bordeaux (commercial) and oil	Ditto	Ditto	0.1	2.5
		None	——	——	30.0	
		None	——	——	60.0	45.0
6	2	Liquid lime-sulfur	Late fall	10–23–27		
		Liquid lime-sulfur	Spring	2–20–28	4.2	
	2	Liquid lime-sulfur (½ strength)	Ditto	Ditto	15.7	
	2	Liquid lime-sulfur and oil	Ditto	Ditto	5.6	
	2	Dry lime-sulfur	Ditto	Ditto	11.5	
	2	Bordeaux (home-made)	Ditto	Ditto	17.8	
	2	Bordeaux (commerical) and oil	Ditto	Ditto	1.9	9.0
		None	——	——	35.0	
		None	——	——	25.0	30.0

4. Liquid lime-sulfur, full dormant strength gave the most uniform and best control.

5. There was little difference between the effectiveness of the other sulfur sprays in any one block.

6. Bordeaux mixture applied early in the fall seemed to be practically as effective as the sulfur sprays (blocks 2, 5), whereas, in the late fall or spring, it was not as effective as the full strength liquid lime-sulfur (blocks 1, 3, 6).

From these and similar experiments, it seems clear that the time of application of sprays is of most importance in the control of peach rust. Early fall spraying (October 15–November 1) seems to be the best time regardless of material or dilution. In general, however, liquid lime-sulfur has proven most consistent in its effectiveness against peach rust when applied at various times.

An Efficient Oven for Drying Plant Material

By A. E. Murneek, *University of Missouri, Columbia, Missouri*

WHEN large quantities of plant material have to be prepared for subsequent chemical analysis a convenient, efficient, and inexpensive method of preservation becomes a decided necessity. Dessication is by all odds the best means for accomplishing this purpose. Preservation with alcohol and similar reagents is, as a rule, a more complicated and costly procedure. It is also subject to greater error, since extract and residue usually have to be analyzed separately. Moreover, alcohol leads to precipitation of certain proteins. Freezing, though a satisfactory method in many respects (5), requires special equipment and, with some plant tissues at least, seems to have a distinct undesirable effect on the nitrogenous compounds (8).

Not all temperatures, however, are equally desirable for the drying of plant material. Caramelization of sugars and coagulation of soluble proteins seems to occur at high temperatures (80–100 degrees C), while changes in carbohydrates due to enzymatic action and proteolysis of nitrogenous constituents often take place when relatively low heat (30–45 degrees C) is used (2, 3, 4, 8). The optimum temperature for most tissues appears to be around 60–65 degrees C, with a possible range of 50–75 degrees. This temperature has been found to be the most desirable for the preservation of a large variety of tissues (2, 8, 3, 7, 6). It has produced the least alteration in the amount of the various carbohydrate and nitrogenous compounds as evidenced by comparative analysis of fresh and dried material. Within these limits, the lower the temperature the slower, naturally, will be the rate of dessication, and *vice versa*. But some plant material, like leaves and finely divided wood, will lose their moisture content in a reasonably short time even at 40 degrees C (1) if the drying chamber is properly ventilated.

Rapid aeration is of primary importance in the successful dessication of any type of plant material. This can be secured only when the oven is of relatively large size and has an equipment for forcing or drawing air through it. Moreover, it should be so constructed that the heated air passes not merely over the material but also through the trays upon which it should be spread in a thin layer. Trays of good wire screen usually are best for this purpose. In this connection it should be kept in mind that the more finely divided the material is the more rapidly will it lose moisture. Most plant tissues should be cut into pieces less than ½ cm. square. Consequently when a comparatively large volume is to be handled this can be done with dispatch only if an adequate force of assistants is employed.

The writer has used successfully for some time a drying oven, which has been satisfactory and serviceable in most respects. A description of the construction and efficiency of this equipment may be of interest to horticulturists and other persons concerned with the chemical analysis of plant material.

This oven is of the "home dehydrator" type and of a cabinet form: 60 inches high, 22 inches wide, and 60 inches deep (Fig. 1). It has a capacity of 36 square feet, and, therefore, with a minimum load of

1 pound per square foot will handle about 40 pounds in one charge. It is constructed of heavy galvanized iron and for most part lined with thick asbestos paper. There are eight inclined trays of heavy wire mesh in the main chamber and three in the "curing room" (Fig. 2).

Although heat for the dehydrator can be supplied by gas or steam, the writer has found most convenient to use a 4-unit electric heater, each unit having a separate switch (Fig. 3).

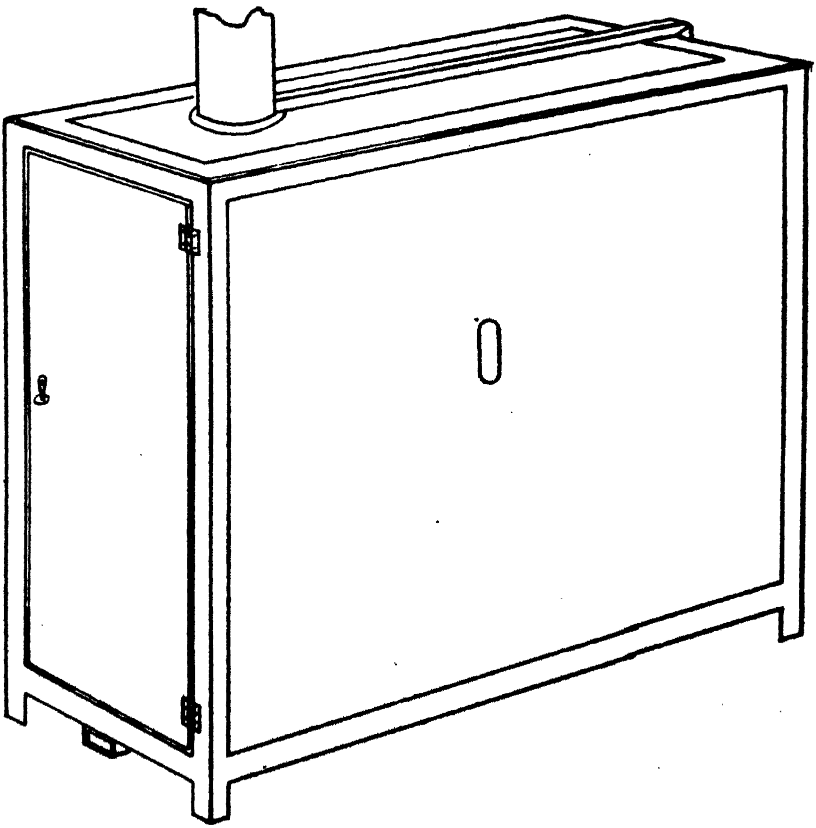


FIG. 1. Perspective of dehydrating unit.

An oscillating electric fan of the "whirlwind" type, attached horizontally to the door, assures very forceful ventilation. By regulating the speed of the fan and by adjusting the damper in the air outlet pipe, the rate of air movement in the chamber may be easily controlled. In general the equipment permits the adjustment of both ventilation and temperature within a wide range, which can be still further extended by the use of a larger fan, additional heating units, and a rheostat control. With one heater on, the temperature of the main drying chamber can be maintained around 45 degrees C,

with two heaters—55 degrees C, three—65 degrees C, and all four—75 degrees C. The fan is usually run at full speed and the damper kept wide open, thus securing maximum ventilation. It should be pointed out that these temperatures cover the optimal range of desirable heat for the dessication of plant tissues.

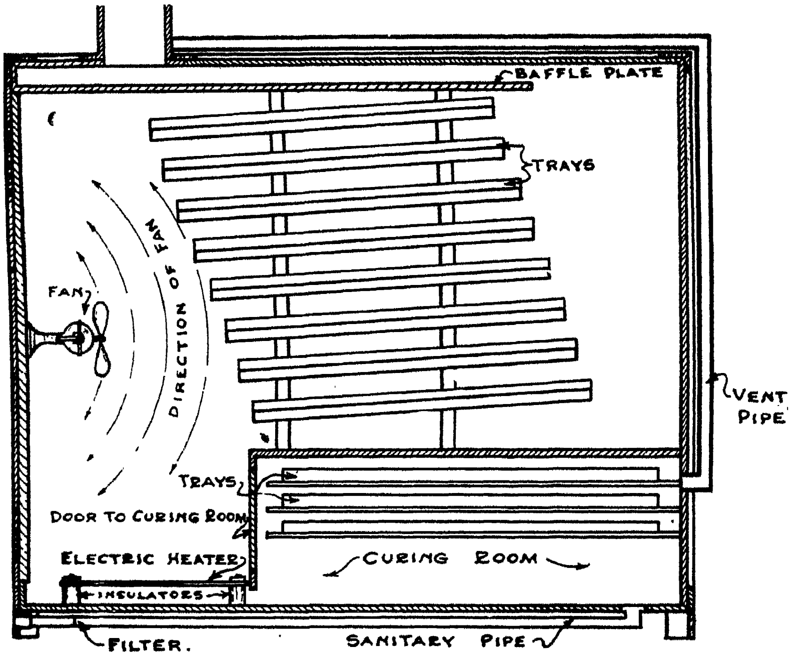


FIG. 2. Longitudinal section.

The appended table shows the time required for the complete dessication of certain plant organs when cut into pieces approximately .5–1 cm. square. Leaves and very fine twigs, of course, were dried whole.

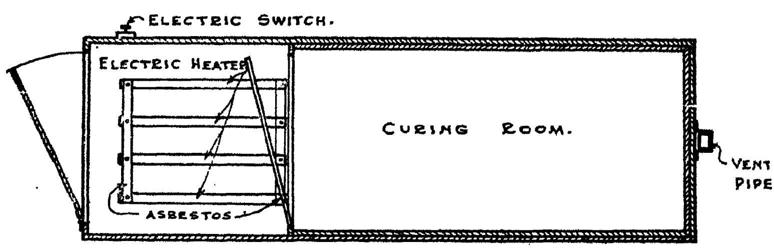


FIG. 3. Plan of dehydrating unit.

It will be noted from this table that practically any commonly used tissues can be dessicated at 65 degrees C within 2–6 hours, thereby making it possible to finish the work within a day. The slight variations in time of drying in each instance were due to several

TABLE I—TIME OF DESSICATION OF PLANT MATERIAL

	2 Heaters (55 Degrees C) Hours	3 Heaters (65 Degrees C) Hours	4 Heaters (75 Degrees C) Hours
Potatoes			
Tubers (mature)	8–10	6–7	5–6
Stems	6–8	4–5	3–4
Leaves (green)	5–6	—	2–3
Tomatoes			
Stems	7–9	5–6	4–5
Leaves	5–6	3–4	2–3
Fruit (green)	8–10	—	5–6
Apples			
Wood (3–6 year)	7–9	—	5–6
New Growth	6–7	4–5	3–4
Spurs	6–7	4–5	3–4
Leaves	3–4	2–3	1.5–2
Fruit	8–9	—	5–6
Peaches			
New Growth	6–7	4–6	3–4
Leaves	2–3	1.5–2	1–1.5
Grapes			
Canes (new)	7–8	—	3–4
Leaves	3–4	2.5–3	2–2.5

minor factors, such as the initial heat of the oven, frequency of opening the door, size of the cut pieces, the amount of material per tray area, the total initial load, etc. Generally these differences are of small significance, the total time of drying being as brief as one may reasonably expect.

In conclusion it should be pointed out that this dehydrator is admirably adapted for studies of dessication of all sorts of vegetables and fruits, for the rapid curing of field crop plants, the drying of seeds and for many other purposes, where not only temperature but also ventilation is an important factor. And for very extensive work a battery of several dehydrators may be used.

LITERATURE CITED

1. CHIBNALL, A. C. Investigations on the nitrogenous metabolism of the higher plants. III. The effect of low-temperature drying on the distribution of nitrogen in the leaves of the runner bean. Biochem. Journ., 16:599–607. 1922.
2. LINK, K. P. Effects of method of dessication on the carbohydrates of plant tissues. Journ. Ame. Chem. Soc., 47:2:470–476. 1925.
3. LINK, K. P., and SCHULZ, E. R. Effect of the method of dessication on the nitrogenous constituents of plant tissue. Journ. Ame. Chem. Soc., 46:9: 2044–2050. 1924.
4. LINK, K. P., and TOTTINGHAM, W. E. Effect of the method of dessication on the carbohydrates of plant tissue. Journ. Ame. Chem. Soc., 45:2:439–447. 1923.
5. NIGHTINGALE, G. T., ROBBINS, W. P., and SCHERMERHORN, L. G. Freezing as a method of preserving plant tissues for the determination of nitrogen fractions. N. J. Agr. Exp. Sta. Bul. 448. 1927.
6. OSBORNE, T. B., and WAKEMAN, A. J. The proteins of green leaves. I. Spinach leaves. Journ. Biol. Chem., 42:1–26. 1920.
7. THOMAS, W. Influence of temperature of dessication on water-soluble nitrogenous constituents and separation of water-soluble protein from non-protein constituents. Plant Physiol., 2:1:55–66. 1927.
8. TOTTINGHAM, W.E., SCHULZ, E. R., and LEPKOVSKY, S. The extraction of nitrogenous constituents from plant cells. Journ. Ame. Chem. Soc., 46:1: 203–208. 1924.

Determining Moisture in Living Plant Tissues*

By A. N. Wilcox, *University of Minnesota, St. Paul, Minnesota.*

THE purpose of this paper is to bring to the attention of horticulturists a method by which the free water content of living tissues can be determined electrically, and to present an adaptation whereby a number of determinations can be made upon several loci in rapid succession and repeated upon the same respective loci at intervals.

The method involves the use of the Zeleny Moisture-meter, devised originally by Dr. Anthony Zeleny (1) of the Department of Physics of the University of Minnesota, to facilitate instant measurement of the moisture content of corn, lumber, or similar material. Dr. William Robinson, (2) while in the Department of Entomology and Economic Zoology of the University of Minnesota, applied and adapted the method for use with certain living tissues and gave clear directions for its construction and use.

The method consists essentially of measuring the electrical conductivity of the tissue. After the apparatus is assembled and calibrated, the actual testing consists of three steps. First, a pair of small needle-like electrodes which project parallel to each other from an insulating handle are inserted into the material to be tested. Second, a minute current is applied to the electrodes. Third, the deflection occurring on the scale of a galvanometer which is connected in series with the rest of the apparatus is observed and noted. The degree of deflection has been found, with the tissues studied, to vary in proportion to the moisture content of the tissues. For example, with sound commercial stored corn the instrument showed the moisture within an accuracy of one-tenth of one per cent when checked with analyses made by the standard Duval method.

The apparatus as used by Robinson consisted of a small storage battery connected in series with a high resistance of one million ohms, with a sensitive galvanometer, and with the electrodes. The electrodes were made from fine steel insect pins set parallel to each other from about one to three millimeters apart, in hard rubber encased in a metal tube slightly smaller than a lead pencil. The pins projected about one-half centimeter or less from one end of the holder and were soldered to fine copper wires which extended out the opposite end. The battery was connected to a rheostat and to a voltmeter in order that the potential might be regulated. A commutating switch was also installed for the purpose of reversing the current at the electrodes at will. The outfit was assembled from laboratory apparatus, but is also obtainable in a compact and portable form.

With a few additions and changes this apparatus can be arranged to carry a number of pairs of electrodes, which can be placed, for example, in different parts of the branch or twig of an apple tree.

*Published with the approval of the Director as Paper No. 823 of the Journal Series of the University of Minnesota Agricultural Experiment Station.

The electrodes are attached to a many-way switch, as shown in Figure 1, so that the respective pairs can be thrown into the circuit successively. A series of readings of free water content can then be taken as rapidly and conveniently as a series of temperatures can be determined by the thermocouple method.

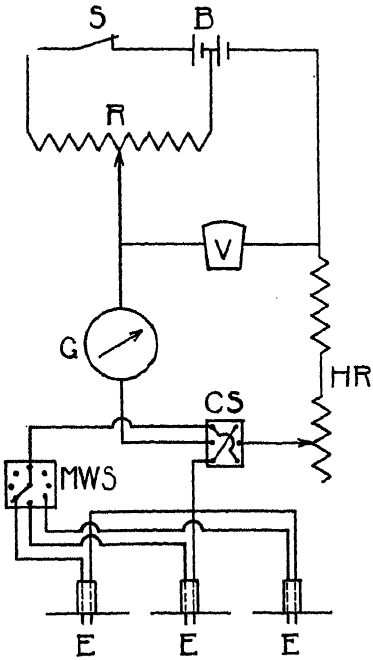


FIG. 1. Diagram of apparatus for use in electrical method of determining moisture at several loci.

The electrode holders designed by Zeleny and by Robinson were suitable to be held in the hand like a pencil for the purpose of pushing the electrodes into the substance to be tested. A different form of holder, shown in Figure 2, has been found by the author to be more suitable for semi-permanent attachment. A shorter tube is used and wings or lugs are affixed to the electrode end of the tube to form a base by which it can be attached with tacks or bands to the tree branch or other object to be tested. The basal wings are made of metal which can be bent with pliers into a shape conforming to the surface upon which the instrument is to be attached. It should be noted that the hard rubber in which the electrodes are fixed extends to a definite distance from the tips of the electrodes so that the points can always be inserted the same distance into the branch. A groove in the rubber between the electrodes aids in preventing the formation of a film of moisture which would short-circuit the electrodes at the surface of the material. If the electrodes are to be left in place for a considerable time they are made from some corrosion-resisting metal rather than from steel. The length of the points, their size, and their distance apart, are governed by the purpose for which they are to be used.

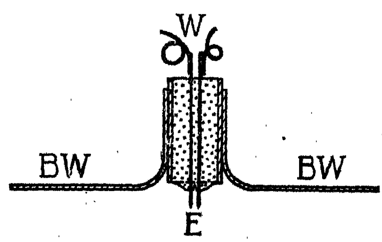


FIG. 2. Vertical section through electrode holder, showing: E, electrodes for insertion into tissue to be studied; W, wires; and BW, basal wings for the purpose of attachment.

To attach the electrodes, the experimenter first bends the basal wings into suitable shape, then presses the electrodes straight into the object to be tested, and next fastens the apparatus firmly in

place so that no movement of the electrodes can occur during the progress of the experiment. If part of the branch is cut away, the exposed tissue should be protected from evaporation. If the apparatus is exposed to the weather, suitable protection should be provided to prevent collection of external moisture at the electrodes. After the electrodes are put in place they are connected to the rest of the apparatus, which can be located some distance away under shelter.

When the current is turned on, the galvanometer shows a deflection which almost instantly reaches a point proportional to the moisture content, and then slowly falls off due to polarization. Consequently, the current should be left on only long enough for a reading to be made. The direction of the current can be reversed, if desired, by use of the commutating switch, and the average of the two readings used. This overcomes the effects of polarization and also of any minute differences of potential which may exist in the living tissue.

Inasmuch as moisture is not the only factor which governs the conductivity of tissues, it is important to check and calibrate the apparatus under the conditions and upon the type of tissue to be studied. It has been found that the deflections obtained with different materials may have slightly different corresponding values of moisture. For example, corn that has been allowed to spoil while wet gives readings too high when compared with commercial stored corn, while uncured corn taken directly from the stalks gives readings that are too low. The discrepancies may amount to more than 3% at the higher moisture contents. Particular care should be exercised to eliminate the error which might result from changes in the salt content of the tissue.

To calibrate the apparatus, the experimenter uses a single electrode pair and determines the average deflection obtained from each of several loci which give different readings. The percentage of moisture in the respective loci are determined by analysis. These values are then set down opposite the corresponding readings of the galvanometer, and the intervening values are plotted.

Inasmuch as the degree of deflection of the galvanometer depends also upon the size of the electrodes and their distance apart, any additional pairs which are to be used must also be calibrated. This is quickly and easily done by Robinson's method, that is, by comparing the additional pairs with the standard pair with respect to the deflections obtained when the electrodes are inserted the proper distance into standard salt solutions. After the apparatus has been calibrated and set up with the electrodes in position, the moisture content is determined in one of two ways. Either the degree of deflection on the galvanometer scale is noted and later converted to per cent of moisture, or else the rheostat is first set at a point previously determined for each electrode pair and then when the switch is thrown the per cent of moisture is read directly from a scale which has been superimposed upon the galvanometer scale.

It should be noted that the readings vary slightly with temperature. While a difference of several degrees may have no appreciable effect, the greater differences which are encountered over a considerable period out-of-doors may cause a noteworthy error unless the temperatures are recorded and proper allowance made.

The electrical method of determining moisture should be a useful tool in certain physiological investigations, and especially in those which are important to horticulture. The water in tissues has been shown by a number of studies with plants, and with other organisms as well, to have an important bearing upon, for example, hardiness and dormancy. Most of the studies of the water content of plants have dealt with relatively gross material, such as whole twigs or branches. Determinations made upon such material have involved the lumping together of a number of different kinds of tissues, possessing structural, physiological, and functional differences. The electrical method makes possible the study of the water content of minute loci. The per cent of free water can be determined instantly without greatly disturbing the tissue. Bound water can be determined indirectly in cases where the total water content can be demonstrated to remain practically constant. The adaptation described herein makes it possible furthermore to study the changes and fluctuations in free water content which occur over a period of time in the same locus and also to extend the determinations to a number of loci at the same time.

The author wishes to acknowledge his indebtedness to Dr. William Robinson and to Dr. Anthony Zeleny for their kind help and many suggestions concerning the use and applications of the electric method.

Literature Cited

1. Zeleny, Anthony. An electrical method for the measurement of the amount of moisture in grain and other materials. Minnesota Engineer. 17:163–170. 1909.
2. Robinson, William. An electric method of determining the moisture content of living tissue. Ecology. 7:365–370. 1926.

Electrodialysis As a Means of Determining Hardiness in Apples

By Fan Chi Kung, *Iowa State College, Ames, Iowa.*

THE hardiness problem in apples has engaged the attention of the Pomology Section of the Iowa Agricultural Experiment Station for many years. After the work of Moore *et al* (1), on electrodialysis as a means of studying biochemical differences in abnormal apple tissue, the present work was suggested by Professor T. J. Maney, and was carried out in the same laboratory. The same Mattson cell was used with the only modification of adding a stirring rod run by a stirring motor. A voltage varying from 112 to 116 was used thruout the experiments. After several trials, it was found necessary and convenient to change the solutions at the following intervals: End of first hour, second hour, fourth hour, eighth hour, and twenty-fifth hour. The time of analysis was extended up to 50 hours as a test, and it was found that even in this period all dialysable materials were not removed. The amperage developed was usually between 2 and 2.7 at the end of the first hour, below one in the second hour, and fairly constant with only a slight decrease up to the end of the twenty-fifth hour.

The preparation of plant material differed according to samples. For March samples, the previous season's growth was taken, dried at 22°C and then ground with a Wiley mill to pass a half millimeter mesh sieve. For June samples, the current year's growth was taken, the fresh tissues ground in a meat chopper, weighed, and put into the cell to be dialysed immediately. Later modifications, aimed to in-increase the permeability of the cells before dialysing, included the practice of adding alcohol or boiling with distilled water after the tissues have been ground and weighed. The alcohol method was discarded immediately as its use in the center cell created a difference in osmotic pressure, drawing water from two outer cells. For air-dried March apple meal, 10 grams of each sample were taken; and for fresh June samples, 20 grams were used.

Some of the data obtained are presented in the following two tables. Table I shows the values in cubic centimeters of N/10 alkali

TABLE I—Cubic Centimeters of N/10 Alkali and Acid Necessary to Titrate the Dialysed Materials

Time in Hrs.	Cubic Centimeters N/10 NaOH			Cubic Centimeters N/10 HCl		
	Wealthy (29)*	Grimes (27)	Hibernal (25)	Wealthy (29)	Grimes (27)	Hibernal (25)
1	12.30	16.80	12.10	57.60	63.00	50.00
2	16.52	22.25	15.58	63.42	67.87	54.00
4	24.17	31.48	20.65	66.76	71.79	56.00
8	37.12	45.07	29.85	70.58	76.51	58.76
25	77.42	77.17	54.65	79.94	80.61	64.01

*Numbers in parentheses indicate number of experiments.

and acid necessary to titrate the dialysed materials obtained from summer wood of three varieties. This table shows no correlation in

the values obtained by electrodialysis and the relative actual hardiness of different varieties as proven by Iowa test winters. Ordinarily Wealthy is considered to be a fairly hardy variety but its values are much closer to Grimes than they are to Hibernal, one of the more hardy varieties.

Table II gives some of the values obtained from Hibernal and and Grimes, indicating the more variable results obtained from the samples of different varieties. This series of experiments differ from those in Table I in that the samples were boiled after grinding and before dialysing.

TABLE II—RESULTS WITH OTHER VARIETIES

Time in Hrs.	Cubic Centimeters N/10 NaOH				Cubic Centimeters N/10 HCl			
	Hibernal		Grimes		Hibernal		Grimes	
	(34)	(35)	(37)	(38)	(34)	(35)	(37)	(38)
1	26.75	26.55	28.80	22.24	86.25	76.00	83.50	72.00
2	33.50	32.25	36.45	28.49	95.88	84.80	92.50	78.45
4	42.00	41.10	45.39	36.24	99.27	87.66	94.89	80.98
8	56.15	54.35	58.39	50.24	102.23	90.11	96.75	83.94
25	90.55	93.75	104.99	89.89	113.93	100.66	108.12	94.49

Altho most of the values obtained have shown great differences, they all tend to produce the same type of curve if the amount of N/10 acid or alkali is plotted as ordinate, and log. time in minutes is plotted as abscissa.

It should be pointed out that solutions from the cathode cell were almost always clear and easily titrated with N/10 NaOH, but that solutions from the anode were very cloudy and highly colored at the first change of solution at the end of the first hour, and less so at the following changes. In some cases the potentiometric method was used.

It should also be recorded that during the last interval between the eighth and twenty-fifth hour, there was a tendency for the water in the anode cell to flow to the cathode cell. No device has yet been made to maintain the solution in all cells at the same level.

The data accumulated so far have shown that this method will not serve as a means to determine relative hardiness of different varieties of the apple, as the differences between the different sample of the same variety are sometimes greater than those between the samples of different varieties, and that the values from electrodialysis do not show any correlation with the actual relative hardiness of apple varieties.

LITERATURE CITED

(1) MOORE, J. C., REEVES, R. G., and HIXON, R. M. Electrodialysis as a Means of Studying Biochemical Differences in Abnormal Apple Tissue. Plant Physiol. 2: 313–324. 1927.

A Convenient Arrangement of Field Plots

By W. E. LOOMIS, *Iowa State College, Ames, Iowa.*

ANY system of arranging plots for field experimental work is concerned primarily with obtaining minimum experimental error and maximum convenience. In fertilizer, variety, and rotation tests as practiced by the horticulturist, it is more important that the reliability of a particular figure be known than that it represent exactly the true value for a particular spot in a certain season. We are searching for differences of such magnitude and constancy that they may reasonably be expected to apply in practice. For work of this type several replications of each treatment have come to be considered essential. On the other hand, differences, on reasonably uniform soil, which are too small to be significant without a large number of replications and elaborate systems of correcting for soil variations are of questionable value when they are applied to the widely varying conditions of the growers fields.

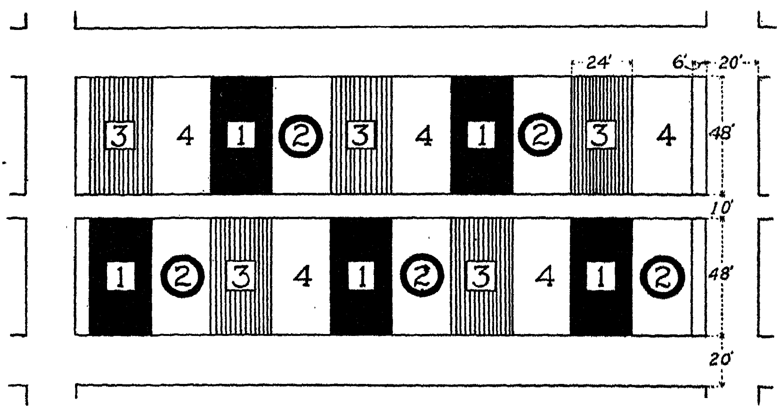


FIG. 1. A plotting plan showing four treatments with five replications. Note the identical pattern for treatments 1 and 2 and the inverted pattern of 3 and 4. Plots 1 and 3 or 2 and 4 are planted and cultivated together.

An arrangement of experimental plots is shown in Fig. 1, which provides for replications under conditions which will give, in a relatively few years, an accurate estimation of all important treatment differences; which is readily adaptable to local needs; and which has proven in use to be exceptionally convenient. This plan of plot arrangement differs from a number of somewhat similar plans which the author has observed in:

1. The use of a double tier of plots rather than a larger number. The distribution pattern of the treatment replications, the accessibility of the individual plots and much of the convenience in preparing the land and harvesting the crops depend upon this arrangement.
2. The combination of an even number of treatments with an odd number of replications, another essential factor in obtaining the distribution pattern.
3. The use of only one alley on a block, with a reduction of border effect and a saving of space without any sacrifice of the advantages

arising from the use of traversable alleys. The long narrow block with a central alley for the dead or back furrow is easily prepared with tractor-drawn implements of common design. The alley prevents fertilizers or harvested crop being dragged from one plot to the next. In harvesting, any row begins at the alley and ends at the road. This space is also conveniently available for surface drainage, irrigation, an occasional or local use of the spray wagon, etc.

4. The use of a road entirely around the block. This space has proven to be well used in increasing the accessibility of the plots, decreasing border effect from tall or spreading crops, and making it possible to prepare each block independently. This last is important in any rotation but particularly so if double cropping or perennials are included in the rotation.

5. The use of a plot size adapted to uniform spacing of rows and hills rather than an attempt to use some fraction of an acre. The use of plot dimensions which are multiples of 12 feet with a plot twice as long as wide is generally convenient. A plot 24 by 48 feet is small enough for peppers and potatoes and large enough for cantelopes and nursery stock. Rows or hills may be uniformly spaced at 12, 18, 24, 28.8, 32, 36, 41.1, 48, 57.6, or 72 inches, so that commercial spacing may be used for all crops without waste of space or unequal exposure of the border rows. In special cases the plots may be 36 or even 48 feet wide and correspondingly longer.

6. The elimination of a large number of "check" plots. Corrections with check plots are never fully satisfactory and we feel that it is safest, on any soil adapted to experimental work, to replicate all treatments three or five times and to use their mean value rather than to attempt a correction for soil variation which is too frequently unjustified. Where pronounced soil differences appear after an experiment is started, however, they may be estimated with this arrangement from any or all of the treatments used and the correction made directly on the plot concerned rather than calculated from nearby plots.

In making a statistical analysis of the data from a series of this sort, odds should be calculated by Student's method rather than Bessel's because of the small number of observations averaged. The value of "z" is obtained by dividing the difference in the means of two treatment series by the standard deviation of the difference (calculated from the deviations of the means) and the odds calculated or obtained from Love's tables. Mean results over several years may be paired by years and the standard deviation of the difference obtained directly.

It has been found especially convenient with this plot arrangement to use a soldered wire marker suggested by Professor Wessels of Cornell University. Galvanized pipe are solidly embedded in concrete at the proper location in the end roads and the corners of the plots or the location of rows are quickly fixed by stretching wire markers between these points, each plot corner or row position being indicated by a short piece of wire wrapped about and soldered to the marker.

Some Serious Weak Points in Field Nutrition Studies With Peaches

By M. A. Blake, *Experiment Station, New Brunswick, N. J.*

DURING a period from 1907 to 1918 the author of this paper conducted two field fertilizer experiments with peaches. Each plot contained not less than 25 trees of Elberta, in each case, and was separated from adjoining plots upon all sides by trees of other varieties. One orchard was extensive enough so that at times not less than a carload of peaches in crates was shipped in a single day. The two experiments provided ample opportunity for one to learn the difficulties that may be encountered in such an experiment and any criticisms of weaknesses are based upon personal experiences and not upon those of other workers.

Although there were 25 trees in each plot in the peach experiments, records were taken of each individual tree over a period of some years, thus affording an opportunity to study the amount of variation which might be expected among peach trees that were treated as nearly alike as possible. A series of comparative treatments of plants have little value if the individual variations are great enough to offset differences between plots. In the case of peach trees, there is likelihood of various factors bringing about marked differences between the behavior of individual trees.

Portions of the experimental orchards at Vineland, New Jersey, were upon a sandy loam soil and certain plots appeared to be as uniform as one could hope to get them. In fact, the soil conditions upon the area selected for an experimental project are likely to be considerably more uniform than under average orchard conditions. Yet, in the experience of the author, trees of the same variety treated as uniformly as possible in an experimental block are likely to vary considerably in total growth, yield, size of fruit, and growth status.

To illustrate this point, the yields of the first ten trees upon plot fourteen at Vineland from 1910 to 1915 are given. Trees in this plot were selected since it was one of the most uniform in the entire orchard.

TABLE I—Yields in Pounds of Ten Peach Trees at Vineland, N. J.

Tree	1910	1911	1912	1913	1914	1915	Total
1	56	91	159	25	147	212	691
2	49	96	161	41	94	215	656
3	48	64	188	18	36	192	546
4	58	78	124	21	159	272	711
5	27	58	190	36	109	215	634
6	54	59	179	21	151	308	772
7	56	64	152	7	165	204	648
8	66	57	130	16	89	267	584
9	65	57	138	12	148	178	597
10	67	96	151	10	187	179	691

The first year that the trees produced fruit the ten trees cited produced quite uniformly, with the exception of No. 5 which was decidedly lighter. The second year, Nos. 10, 2, and 1 gave markedly

better yields than the others. The third season an entirely different trio, Nos. 5, 3, and 6, were outstanding in yield. The highest yield was made by No. 5, the low tree of 1910. The year 1913 shows greatly reduced yields upon all of the trees as a result of *extra* early blooming and injury by cold, so perhaps inferences should not be too closely drawn. Though the season of 1914 was exceptionally favorable, marked variations in the yields of all individual trees are evident, as, for example, between Nos. 10 and 3 the difference is in excess of three bushels. The season of 1915 was also ideal for peaches at Vineland, and a good yield was obtained. A variation in production may be noted between trees No. 6 and No. 9, which amounts to more than 2.5 bushels. The total extreme variation between the highest and lowest yielding tree for the six years amounted to about 4.7 bushels.

One essential of an orchard fertilizer experiment is a sufficient number of trees per plot to offset the individual tree variations. In the experience of the writer, 25 is none too large a number where climatic and soil conditions are decidedly favorable and uniform. If many treatments are to be compared and these duplicated several times, the investigator thus becomes involved in the commercial production of peaches. This means, further, that the operations of tillage, pruning, thinning, spraying, and harvesting must be carried out uniformly and simultaneously over the entire series of plots. Even with an experienced organization it is no easy matter to insure similar treatment to all parts of a large orchard for one season, not to mention six or more. It may sometimes be impossible to spray the entire orchard in one day because of unfavorable weather, and a consequent variable pest control result. It requires eternal vigilance during the spraying season to make certain that each tankful of spray is like every other and that one particular lot does not burn. One or two tanks of an over-caustic spray can put several plots "out of the running" for one or more seasons. The control of the peach borer and red mite must also be uniform, otherwise there is a marked variation in growth status of the trees.

All of the factors likely to cause variations thus far mentioned are those which may occur in the practical management of orchard plots of a good size and number. Unfortunately, these are only a few of the difficulties to be overcome.

One factor which may ruin an orchard fertilizer or nutrition experiment upon peaches is injury by cold. During the period from 1910 to 1915 at Vineland, no twig or wood killing occurred. Bud killing was rather severe in 1913, however, and even injury to such a degree means that the functions within the tree are affected, not only for one season but usually for at least two.

The yields of the ten trees cited at Vineland were decidedly variable in 1914, following the bud injury in 1913. There is a variation in yield between trees Nos. 10 and 3, of slightly more than three bushels in the one season, and this orchard was exceptionally free from cold injury. In a district where twig and wood killing are experienced or where bud killing occurs more frequently than at Vineland, a fertilizer experiment may be doomed from the start.

Injury to the collars of some trees and to the sap-wood causes a check to growth and an abnormally high carbohydrate condition which means abnormal fruits and split pits. The degree of such injury usually varies greatly between trees under the same fertilizer treatment and even between different branches and twigs upon the same tree. In other words, cold injury may change the growth status of a tree or even parts of a tree within any one season, and the effects continue for an indefinite period.

Split pit fruits are abnormal in size, in relative dimensions, in time of ripening, and in quality. Their appearance in any considerable numbers will shoot full of holes almost any orchard nutrition study which involves comparisons in size, texture, and quality of fruits developed under different treatments.

In some of the more recent orchard nutrition studies, trees that appear to be of much the same vigor are grouped into pairs and single trees subjected to treatment, rather than to employ the large plot method. If the trees experience winter injury to the sap-wood even a system of paired tree treatments will not overcome the variations caused by this factor. Two trees of exactly the same growth status one season are often markedly different the next. In addition to the development of split pit fruits, "buttons," and various forms of undeveloped fruits are likely to further complicate the problem.

If the object of an orchard fertilizer experiment is merely to determine the approximate amounts of nitrogen, potash, and phosphoric acid that are most likely to prove profitable on peaches in any given locality, no better method is available than to make actual treatments under the best commercial orchard practice, and information of this kind is needed.

However, even after one has devoted several years to the development of an orchard and has spent much time and expense upon tillage, spraying, thinning, and other operations to insure uniformity of treatment, the data may have but a limited application.

The proper growth status that is necessary to secure good yields of peaches of the right texture and color must be maintained from season to season. The peach is very sensitive to its growing environment, and a bit too much growth with larger leaves may greatly change the color and saleability of the crop.

Two orchard sites of exactly the same soil type may require different fertilizer treatments to obtain the desired results because of differences in treatment practised previous to the planting of the peaches. Further, during a very wet season nitrogenous nutrients should often be reduced from the amounts that are required during a normal season. The point should, perhaps, be emphasized that the author of this paper has no desire to discredit orchard fertilizer experiments for the purposes to which they may be adapted, but, on the other hand, to set forth some of the difficulties which an investigator is likely to encounter who is seeking for fundamental truths in regard to the nutrition and growth of the peach.

From a research standpoint, some important facts to be learned in regard to the peach today are the actual functions of potassium, phosphorus, and other nutrients in the growth of this plant, and the effect, if any, of these elements upon texture and quality of the fruit. The function of iron, magnesium, lime, and other compounds in the growth of the peach and their action and effect in the presence of various compounds and combinations should be better understood. Such objectives are likely to be attained only with great difficulty under orchard conditions.

The writer has further observed a soil condition reported in N. J. Bul. 356 that would prove disturbing to a field nutrition study with the peach. In mild cases, the trees make a good growth, the foliage has a good color and the trees come into bearing quite promptly, but the size of the fruit is never satisfactory even though standard thinning is practised. In more severe cases, the foliage is yellow or yellow-green and the trees have the appearance of early stages of little peach, thus the term "false little peach." In some ways, the trees behave as high carbohydrate trees, but in other ways, they do not. They fail to set buds well and the fruit produced is decidedly small.

Information is available which indicates that this condition may not be caused by any specific pathogene but probably is a nutritional problem. Even a person fairly well experienced in peach culture might not suspect that anything of this sort was wrong with an orchard suffering from a mild case. Liberal applications of a quickly available nitrogen, such as nitrate of soda, have failed to correct the difficulty. If one happened to conduct a fertilizer experiment as to the effect of different sources of nitrogen upon such an area the results would be of doubtful value.

For years the question has been raised as to whether the form or source of fertilizer has any effect upon the texture of tree fruits. The usual orchard fertilizer comparisons have failed to give very definite results. Is not such an approach made from the wrong direction? A given application of even one form of nitrogen does not bring about the same growth status in a peach tree upon a poor soil as in one upon a rich soil, or in an unpruned tree as compared to a pruned tree. Two or more sources of nitrogen may be compared, but suppose they are only utilized when converted to nitrates? Should we not then first determine how nitrogen is utilized by the peach and the true functions of potassium and phosphorus and, further, how various other elements, such as iron, magnesium, and calcium may affect the peach when present in various combinations and forms?

If one is to determine such facts at all promptly and efficiently it appears that better controlled treatments are necessary than those which can be had under field conditions. The so-called sand culture method is more promising from the standpoint of fundamental research.

An Application of the Triangle System in Determining A Nutrient Solution Suitable for Research With the Peach in Sand Culture

By O. W. DAVIDSON, *Experiment Station, New Brunswick, N. J.*

AFTER considering the difficulties encountered in conducting and interpreting orchard fertilizer experiments, it appears that certain nutritional problems on the peach can probably be worked out most efficiently in sand cultures. The purpose of this study was, therefore, to find a nutrient solution suitable for growing the peach in sand culture.

METHODS

In order to avoid variations due to differences in reserve foods in one-year-old peach trees, it was thought advisable to use seedling plants for this study. The use of seedling trees, however, naturally involves inheritable variations in habit and vigor of growth. In connection with peach breeding investigations which have been in progress at this Experiment Station for more than ten years, it has been found that the pits of some seedlings resulting from self-pollinating the Elberta have been strikingly uniform in their character of growth. Accordingly, kernels selected from one of these seedlings, known as Number 34 E, were stratified during the winter of 1927–28, and placed in the hands of the writer by Prof. M. A. Blake. The sprouted kernels were placed in quartz sand in four-inch pots, and were allowed to exhaust the reserve in their cotyledons. At that time, forty of the most uniform plants were selected and transplanted into washed quartz sand in ten-inch clay flower pots.

The physiologically balanced nutrient solutions employed for growing the trees are the same as those in the ammonium sulphate series of Jones and Shive (4). A description of the solutions is given in Table I. The twenty different nutrient solutions, each having a total osmotic concentration of one atmosphere, were prepared from half-molecular stock solutions of analyzed salts.

The siphon system used to deliver a continuous supply of nutrient solutions to the plants was similar to that employed by Robbins (6). An amount of nutrient solution was used sufficient to maintain a constant drip from the bottoms of the pots. One liter of solution per day was sufficient during the first six weeks of the experiment, but later this amount was increased to 1500 cc. Each pot was flushed weekly with distilled water to prevent the possible accumulation of any of the salts used in a concentration toxic to the plants.

After the plants had been grown in sand cultures for a short time, they became chlorotic. The chlorosis was characterized by a loss of chlorophyll, first from the tissues surrounding the smaller veins and then from the smaller veins themselves. The work of Gile and Carrero (1), (2), and of Jones and Shive (3), (4) has shown that iron salts when added to the nutrient solutions will correct this type of chlorosis. Therefore, a freshly prepared solution of ferrous sulphate containing 0.1 mgm. of iron per cubic centimeter was added to the

cultures according to the needs of the plants. For mild cases of chlorosis, 0.1 to 0.2 mgm. of iron per plant per day was adequate to correct the ailment. For the most severe cases, it was not necessary to add more than 0.5 mgm. per plant per day. No signs of iron toxicity were observed.

TABLE I—DESCRIPTION OF SOLUTIONS USED* PARTIAL VOLUME-MOLECULAR CONCENTRATIONS

Total osmotic concentration value of each solution, 1 atmosphere

Solution No.	KH_2PO_4	$Ca(NO_3)_2$	$MgSO_4$	$(NH_4)_2SO_4$
1—$T_1R_1C_1$	0.00211	0.00146	0.01659	0.0014
2— C_3	0.00211	0.00438	0.01185	0.0014
3— C_5	0.00211	0.00730	0.00711	0.0014
4— C_7	0.00211	0.01022	0.00237	0.0014
5— R_3C_1	0.00211	0.00146	0.01185	0.0042
6— C_3	0.00211	0.00438	0.00711	0.0042
7— C_5	0.00211	0.00730	0.00237	0.0042
8— R_5C_1	0.00211	0.00146	0.00711	0.0070
9— C_3	0.00211	0.00438	0.00237	0.0070
10— R_7C_1	0.00211	0.00146	0.00237	0.0098
11—$T_3R_1C_1$	0.00633	0.00146	0.01185	0.0014
12— C_3	0.00633	0.00438	0.00711	0.0014
13— C_5	0.00633	0.00730	0.00237	0.0014
14— R_3C_1	0.00633	0.00146	0.00711	0.0042
15— C_3	0.00633	0.00438	0.00237	0.0042
16— R_5C_1	0.00633	0.00146	0.00237	0.0070
17—$T_5R_1C_1$	0.01055	0.00146	0.00711	0.0014
18— C_3	0.01055	0.00438	0.00237	0.0014
19— R_3C_1	0.01055	0.00146	0.00237	0.0042
20—$T_7R_1C_1$	0.01477	0.00146	0.00237	0.0014

*Ammonium Sulphate Series of Jones and Shive (4).

EXPERIMENTAL RESULTS

Weekly records of the elongation of the main stems of duplicate plants in any one culture show good agreement. Likewise, the appearance of the plants in similar cultural treatments was characteristic. In most cases, plants growing in cultures containing concentrations of calcium nitrate above the unit amount were larger and had a greater number of both primary and secondary lateral branches. On the other hand, where ammonium sulphate was used in concentrations above the unit amount, the plants were invariably smaller and the tendency to branch was less. Furthermore they were characterized by soft, spindly growth and a drooping appearance, and the young leaves at the growing tips occasionally died back. Plants receiving proportions of potassium phosphate above the unit amount tended to be more compact, more branched, and more mature at the time of harvesting, although they were growing nearly as much as other plants receiving less potassium phosphate but corresponding amounts of calcium nitrate and ammonium sulphate. Differences in the color of foliage in various cultures were not great. Plants 1, 2, 3, 4, 11, 12, and 13 were the greenest and, with the exception of No. 1, they were among the largest. The largest plants grown in this experiment were, at the time of harvesting, about 25 per cent larger and somewhat softer, but in other ways comparable to seedling peach trees in nursery rows at this Experiment Station.

In harvesting, the plants were divided into main stems, lateral branches, leaves, and roots. They were weighed separately, cut into small pieces, and dried at 70° to 73° C. for 15 hours in an especially constructed aerated drier. The method employed for handling the roots was similar to that described by Nightingale and Schermerhorn (5). The data secured is presented in Table II on a percentage and absolute amount basis.*

TABLE II—DRY WEIGHT OF PLANTS

Culture Numbers	Main Stem	Lateral Branches	Total Dry Weight of Tops (Leaves Not Included)	Roots	Total Dry Weight of Plants (Leaves Not Included)	Percentage of Dry Matter in Main Stem and Laterals
	Grams	Grams	Grams	Grams	Grams	
1	18.2	15.5	33.7	21.9	55.5	39.7
2	29.4	24.2	53.5	27.5	81.0	38.6
3	27.8	25.6	53.3	25.5	78.8	38.4
4	26.7	24.4	51.0	26.0	77.0	40.0
5	11.1	9.1	20.2	13.2	33.4	38.7
6	15.0	14.8	29.8	18.4	48.2	40.3
7	14.5	14.1	28.6	13.6	42.2	39.2
8	6.7	6.0	12.6	8.4	21.0	40.2
9	10.7	10.4	21.0	11.4	32.4	39.1
10	3.9	2.3	6.2	3.2	9.4	39.8
11	21.6	20.2	41.8	25.1	46.9	39.5
12	27.0	22.6	49.6	23.5	73.1	39.1
13	26.2	27.4	53.6	27.5	81.0	39.7
14	11.5	10.2	21.7	16.9	38.5	38.7
15	17.4	17.4	34.8	23.1	57.8	38.9
16	8.2	7.6	15.7	9.9	20.6	38.8
17	23.5	23.4	46.9	29.4	76.3	39.4
18	26.4	29.1	55.3	29.0	84.3	39.1
19	14.1	15.0	29.1	23.7	52.7	37.3
20	19.7	20.4	40.0	25.0	65.0	39.1

DISCUSSION

During a period of fifteen weeks, the best cultures produced normal plants ranging from 43 to 52 inches in height. The most desirable plants were high in absolute dry weight and total linear growth, were well branched, and had good foliage color. They were produced in a rather wide range of proportions between the nutrient salts employed.

It makes little difference whether the green weights of tops, dry weights of tops, dry weights of roots, or total linear growth are plotted as the basis for comparison of cultures, for the resultant graphs will be similar. The total yields of dry matter in main stems and lateral branches were arbitrarily chosen and arranged in descending order as is shown in Fig. 1. The figure shows that high yields are associated with medium to high proportions of calcium nitrate and low proportions of ammonium sulphate. The proportions of magnesium sulphate and of potassium phosphate have comparatively little effect upon yields. It also shows that low yields are associated with the higher proportions of ammonium sulphate.

*The dry weights of leaves were not determined.

The value of ammonium sulphate in the cultures used in this study is obscure. Wolkoff (6), and Jones and Shive (4) have shown that better results are obtained from the growth of some plants in cultures containing low or medium low proportions of ammonium sulphate than are obtained without the use of this salt. Supplementary work

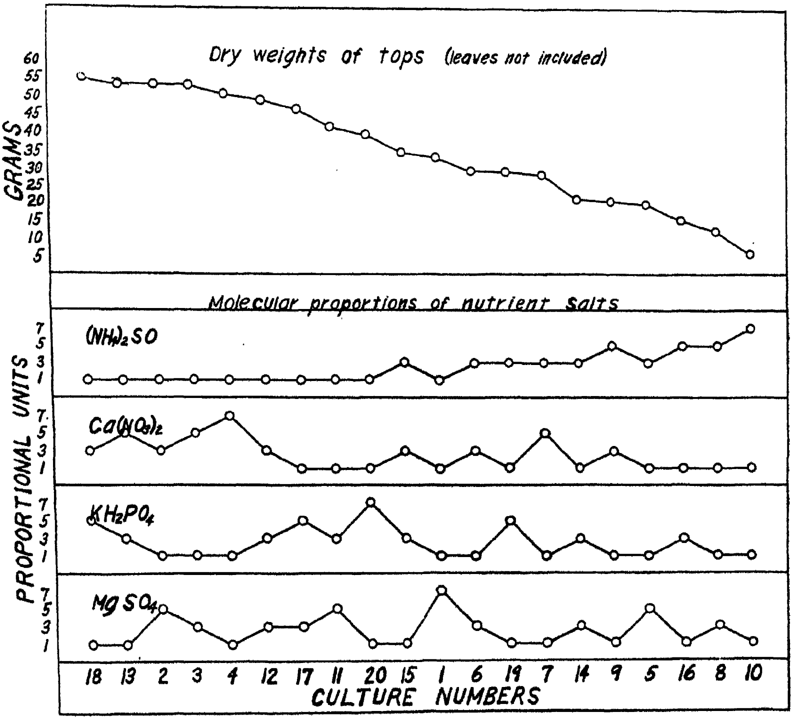


FIG. 1. Dry weights of tops arranged in descending order compared with molecular proportions of nutrient salts in the solutions.

by the writer this summer showed that peach plants in cultures containing low proportions of ammonium sulphate but no calcium nitrate grew slowly and were healthy, while similar cultures containing a higher proportion of ammonium sulphate produced smaller trees and caused the tips of some plants to die back. When calcium nitrate was added to these solutions, vigorous and healthy plants were produced. Thus, ammonium sulphate in small proportions may not be toxic to peach seedlings, but may be beneficial to their growth in sand cultures.

CONCLUSION

A nutrient solution having an osmotic pressure of one atmosphere and having the following salt proportions: 0.01055 molar KH_2PO_4, 0.00438 molar Ca $(NO_3)_2$, 0.00237 molar $MgSO_4$, and 0.0014 molar

$(NH_4)_2SO_4$ was found suitable for growing peach seedlings in sand culture. Under the seasonal environmental conditions of the greenhouse, the solution produced maximum dry weight yields and total linear growth.

Literature Cited

(1) GILE, P. L., and CARRERO, J. O. Immobility of iron in the plant. Jour. Agr. Res., 7:83–87. 1916.

(2) ———, ———. Assimilation of iron by rice from certain nutrient solutions. Jour. Agr. Res., 7:503–528. 1916.

(3) JONES, L. H., and SHIVE, J. W. The influence of iron in the forms of ferric phosphate and ferrous sulphate upon the growth of wheat in a nutrient solution. Soil Sci., XI:93–99.

(4) ———, ———. Effect of ammonium sulphate upon plants supplied with ferric phosphate and ferrous sulphate as sources of iron. Jour. Agr. Res., 21:701–728. 1921.

(5) NIGHTINGALE, G. T., and SCHERMERHORN, L. G. Nitrate assimilation by asparagus in the absence of light. N. J. Agr. Exp. Sta. Bul. 476:5–6. 1928.

(6) ROBBINS, W. R. Nutrient requirements of the sweet potato plant when grown in sand culture, and effect of various nutrient salt proportions on the composition of the roots. N. J. Exp. Sta. Ann. Rpt., 178–179. 1927.

(7) WOLKOFF, M. I. Effect of ammonium sulphate in nutrient solution on the growth of soy beans in sand cultures. Soil Sci., V:123–150. 1917.

Premature Heading in Cauliflower as Associated with the Nutrient Treatment and Chemical Composition of the Plant*

By W. Rei Robbins, *Experiment Station, New Brunswick, N. J.*

CATSKILL Snowball cauliflower seedlings, transplanted and grown in soil until they had two or three true leaves, were transferred after washing the roots carefully, to sand in eight inch clay pots, each pot placed in an enamel pan. Five hundred of these cultures were grown in the greenhouse and supplied with a complete nutrient solution. The period of the experiment was from the middle of April until June, 1928.[1]

At the end of four weeks growth in sand culture, 40 of the 500 plants were harvested and analyses made separately of the blade, stem and petiole, and root tissue, for nitrogenous constituents and carbohydrates. The same nutrient treatment was continued on a part of the remainder. The sand in the pots of another group of the remainder was thoroughly washed to remove soluble nitrogen, the old pots were replaced with new clean pots without disturbing the roots, and the group was given a nutrient solution lacking nitrogen, but otherwise complete.

At the end of three weeks, the plants receiving the complete nutrient solution were larger, had a darker green color than those receiving the minus nitrogen solution, and exhibited a vegetative growth of a type which in the field would be expected to produce a large plant and a marketable head. Some of the plants in this group were kept in the greenhouse and later produced heads.

The rate of vegetative growth of the plants receiving the minus nitrogen nutrient solution decreased considerably. The foliage was light green, the petioles were short, the flower buds were starting to form, and the plants exhibited the condition recognized in the field

TABLE I—Percentage Dry Matter, Total Carbohydrates, Nitrate and Total Organic Nitrogen* of the Stems and Petioles of Vegetative and Prematurely Heading Cauliflower Plants

Type of Plants	Dry Matter	Total Carbohydrates	Nitrate N	Total Organic N
Vegetative.......	9.17	30.0	1.06	2.48
Prematurely Heading.......	11.74	41.0	none	1.21

*Total carbohydrates, nitrate, and total organic nitrogen of stems and petioles are expressed as percentages of dry matter.

as premature heading or "buttoning." At that time analyses were made, as before, of the strongly vegetative and the prematurely heading plants, using methods previously described (1), (2).

*Paper of the Journal Series, N. J. Agricultural Experiment Station. Division of Horticulture.

[1]The author wishes to acknowledge the material cooperation of L. G. Schermerhorn and G. T. Nightingale during the course of this experiment.

Table I shows that the total carbohydrate content of the stems and petioles, probably the chief storage organs, of the prematurely heading plants was greater than that of the vegetative plants, 41 percent compared with 30 percent. The total organic nitrogen of the prematurely heading plants was 1.21 percent, whereas in the vegetative plants it was 2.48 percent. There was no nitrate nitrogen present in any part of the prematurely heading plants at the time of analysis, while in the vegetative plants, nitrate nitrogen constituted 1.06 percent of the dry matter of the stem-petiole tissue.

In general all parts of the plant in the prematurely heading condition had a low percentage of dry matter and total carbohydrates, and a low percentage of total organic nitrogen. Of course this condition might be brought about by other methods which would limit the transformation of inorganic nitrogenous salts to organic forms of nitrogen such as restriction of the water supply, exposure to extremes of temperature or light, or various combinations of these conditions. Under the condition of this experiment, however, premature heading caused by limiting the supply of nitrogen in the nutrient solution was associated with a low percentage of assimilated nitrogen and a high percentage of carbohydrates in the plant tissue.

More complete details of this experiment, including determinations of various nitrogenous and carbohydrate fractions of the stem-petiole, root and blade tissues will probably be published in a bulletin from the New Jersey Agricultural Experiment Station.

Literature Cited

1. Nightingale, G. T. The chemical composition of plants in relation to photoperiodic changes. Wis. Agr. Exp. Sta. Res. Bul. 74. 1927.
2. Nightingale, G. T., and Robbins, W. R. Freezing as a mthod of preserving plant tissue for the determination of nitrogenous fractions. N. J. Agr. Exp. Sta. Bul. 448. 1927.

Some Mulching Materials and Their Effects Upon the Growth of Greenhouse Tomatoes

By I. C. Hoffman, *Experiment Station, Wooster, O.*

ONE of the old established practices of greenhouse tomato growers is that of mulching the crop with manures, straw, or other organic materials some time after the crop has been started. The mulching operation consists in carrying by hand basketfuls of the material into the houses and scattering them evenly over the surface of the ground between the rows and around the plants to a depth of 3 to 6 inches. It is often applied at the rate of 40 or 50 to 100 tons per acre. This operation is very expensive and extravagant of materials and labor. Justification of the cost of materials, time, and labor has been attributed to a number of so-called "advantages" as, (a) conservation of moisture, (b) keeping the soil cooler in the hot summer, months, (c) saving in labor in cultivating, (d) keeping down weeds, (e) saving in labor in watering so often, (f) preventing the soil from being packed hard by tramping while it is wet, etc.

So wide has the variation been in the behavior of the crop that the predicted result failed to appear, giving rise to doubts about the validity of these statements. Experiments have been outlined to discover the effect of mulching with var'ous materials upon the growth of the tomato under greenhouse conditions.

Experimental Work

Rather late in the spring of 1928 certain greenhouses became available at Cleveland, Ohio, for experimental work and one of the beds which was approximately 12 ft. by 90 ft. in size was divided into plots 10 ft. by 12 ft., for the mulching trials. The ground was uniformly prepared by spading under an application of well-rotted stable manure with a supplementary application of a complete, 5–13–4, fertilizer at the rate of about 1400 pounds per acre.

Well-grown plants of the Livingston Globe variety were planted in the bed April 3d. Each plot contained 27 plants arranged in three equidistant rows with 9 plants in each row. The plants responded to growing conditions quickly and a perfect stand was established. The soil had also just been steam sterilized with the pan method and no wilt developed during the season.

The experiment was planned to include the mulching materials that are commonly used in the Cleveland district. These are well-rotted horse manure, fresh strawy horse manure, fresh horse manure in which wood shavings were the absorbing material, and steamed garbage from the city disposal plant. A few growers use dried tobacco stems in limited quantities for mulching purposes, and so this was included. Then in order to get the effect of carbohydrate materials that were as free as possible from nitrogen, chopped dry corn stover was added to the list.

The well-rotted manure, fresh strawy manure, fresh shaving manure, and chopped corn stover mulches were applied May 18th,

and the garbage and tobacco stems were applied May 25th, because they could not be obtained earlier. Two plots were left unmulched to serve as checks.

By May 31st distinct yellowing in the tops of the plants accompanied by retarded growth was beginning to appear in the three manure plots. It was the most pronounced in the plot mulched with fresh strawy manure and the least in that one on which the well-rotted manure was put. The plants in the checks were a dark green color from the base to the top and were growing rapidly. The plants in the other plots appeared at this date to be in as good condition as the checks, but by another week they, too, in every case showed the same symptoms of yellowing in the tops and retarded growth that had appeared in the manure mulched plots just described. The difference in general appearance between the mulched and unmulched plants maintained itself throughout most of the season.

The unmulched plants grew more rapidly, set more fruit, and reached the height at which they were stopped quicker than the mulched ones. The mulched plants did continue to grow and set fruit during the season and finally yielded about the same number and weight of fruit as the unmulched plants did, but it took longer to do it. The indications were that if the check plants had not been stopped, but allowed to continue to grow for a longer time the mulched plants would not have equaled the unmulched ones either in numbers of fruit set or in the weight of fruit produced. The results of the experiment are tabulated in Table I.

These greenhouses were about eighteen years old, and the beds were the flat type. The soil had never been changed, neither had it ever been sterilized by any method. In the earlier years, the houses were yielding satisfactory crops, but later the yields became lower and lower so that for the three years preceding the beginning of the experimental work the houses had been abandoned. The soil in the meantime had become so full of soluble salts that plants could no longer survive in it. The method used to correct this condition was to sterilize the soil by the pan method keeping the pan on the soil for at least an hour after the temperature was up. This method has been found satisfactory by Bewley at the Cheshunt station for breaking down such slowly soluble and likewise very toxic compounds as chlorates and perchlorates into simpler and more easily soluble substances. The tomato plants were set into this soil as soon as it was sufficiently cool, and then the bed was leached by applying large quantities of water. Since in this particular case no drainage tile underlay the bed, the leachings could not drain away but were carried down into the subsoil. This, however, permitted the tomato plants to establish themselves in the soil and growth started immediately. They continued to grow rapidly and began to blossom and set fruit early.

The first picking of ripe fruit was made on June 30th. Pickings were made regularly from then on until August 30th, when the plants had to be removed to prepare the ground for a fall crop. Since

TABLE I—SOME MULCHING MATERIALS AND THEIR EFFECT UPON THE GROWTH OF GREENHOUSE TOMATOES

Plot* No.	Treatment	Total No. Fruits	Total Wt. Lbs. per Plot	Average Wt. Lbs. per Plant	Average Wt. Oz. per Fruit	No. Fruits per Plant	Per cent No. 1 Fruit		Gain or Loss by Treatment Lbs. per Plant
							No.	Wt.	
1	Rotted Manure	548	120.75	4.47	3.52	20.3	65.10	82.40	—0.22
2	Fresh St. Man.	537	95.75	3.53	2.88	19.9	61.45	66.05	—1.16
3	Fresh Shav. Man.	633	141.50	5.24	3.55	23.4	57.34	71.90	+0.55
†4	Check	665	126.62	4.69	3.04	24.6	48.42	67.78	
5	Steamed Garbage	633	123.25	4.56	3.10	23.4	49.92	67.74	—0.13
6	Tobacco Stems	582	128.00	4.74	3.52	21.5	54.46	66.01	+0.05
7	Chopped Corn Stover	541	134.00	4.93	4.16	20.0	65.06	75.37	+0.25

*Plants per Plot, 27. †Ave. of two plots.

the picking period was so short the total yields are low, but the responses of the tomatoes to the mulches appear to be quite characteristic.

The yields for the two check plots were averaged and these figures are presented in the table as Plot 4. The yields for these checks were very close, so the results reported are representative of unmulched conditions. It will be noted that the unmulched plots yielded a larger number of fruits for the season than any of the mulched ones did, but the size of the fruits was a little smaller. The plot having the fresh strawy manure yielded the lowest in both number and weight of fruits. This treatment seems to have been the least desirable of the series, and to the observer the injury was the most outstanding. Fresh shaving manure returned the greatest weight of fruit per plant and the largest fruits. In numbers, it ranked slightly lower than the check.

Probably the most surprising result was the response made to the application of well-rotted horse manure. This plot yielded lower in number of fruits and weight per plant than one would expect. If there is anything to the theory that plant food is leached from the mulch to the soil it should show here. Apparently no such action took place to any considerable extent. The weight per plant on this plot was less than that of the checks, although the weight per fruit was slightly more. The difference, however, in numbers of fruit produced was so much that there was a loss due to the treatment.

Steamed garbage is being used around Cleveland instead of manure since the latter is so hard to secure. It is not as valuable as a plant food carrier as manure, but may be obtained locally and is being used in large quantities by several growers. As many fruits set on this plot as in the one receiving the shaving manure but the size of the fruits was much smaller. They were also smaller than those on the checks and there was a reduction of total weight per plot.

Tobacco stems have been used for mulching purposes in a few instances, but have never become popular. Corn stover has never been tried in the Cleveland district as far as the writer knows, but this material and the tobacco stems were used in this case to see what effect there would be on the availability of the nitrogen supply by the action of the bacteria of the soil in breaking down the cellulose material. It will be seen in the table the numbers of fruits set on both these plots were less than those on the check. However, the fruits were so large and heavy that they outweighed those of the check. This may lead to the inference that the bacteria acted so slowly on these materials that nitrogen never became a limiting factor. This may be partly true, as the corn stover did not break down rapidly. The tobacco stems were dry and brittle and the continued tramping crushed them into fine bits whence they disappeared. Another factor that tends to cast doubt on the accuracy of this interpretation was that these plots were just inside of double doors which stood open most of the time. Much more air passed over these plants than those toward the interior of the house. Enough

is known now about the speed of carbon dioxide absorption by plants to give rise to the feeling that a considerable part of the increase in size of the fruits in these two plots is due to this factor, and that if this should be eliminated by keeping the doors closed the size and weight of fruits would be about as low as the rest. More work will be done in an attempt to clear up this point. From the results of these mulches there is nothing to commend them to tomato growers as a means of increasing yields.

The cost of manure delivered to the greenhouses in Cleveland is about $5.50 to $6.00 per ton. It is often applied as heavy as 100 tons per acre as a mulch if there is not much bedding material in it. This cost together with the labor of applying it more than off-sets any gains shown for mulches.

Experiment at Wooster

A bed 7 ft. by 50 ft., in the experimental greenhouses at Wooster, Ohio, was set with 120 Marglobe tomato plants August 27, 1928. The plants had been grown in 4-inch clay pots and were stocky, vigorous, and uniform in size. They were set 20 inches by 24 inches apart and subsequently trained to single stems. After setting, the plants were grown as rapidly as possible, since they were set at such a late date.

When the plants were about 24 to 30 inches tall, one-half of the bed was mulched with fairly well-rotted manure from the steer barns. At this time the first cluster of blossoms had opened and the earliest fruits were about one-half inch in diameter. The blossoms on the second cluster were opening and about half of them had set fruit. The rest were still opening and the third cluster in the meantime was expanding and nearly ready to begin blooming. The mulch was applied to a depth of 3 to 4 inches.

The first indication of a difference in the behavior of the two plots appeared about five weeks after the mulch was applied. The unmulched plants seemed to be heavier and were sagging down on their supporting wires more than were the mulched ones. Examination showed that there were more and larger fruits setting on the unmulched plants than on the mulched ones. This difference continued throughout most of the season. The differences in number and weight became less about the first of December—one month after picking started, and continued to be rather close after that time. By actual count there was a difference of only nine fruits between the two plots on December 20. These extra ones are on the mulched end, but since the average size of the tomatoes on the mulched bed is somewhat less than the unmulched the weights of the remaining fruits will be approximately the same in both plots.

The results of the two treatments are presented in Table II along with other data that have been secured by analyzing the yield records. The accompanying graph shows the daily picking record from the first picking, November 2nd to December 20th inclusive. The graph brings out the striking differences in the rate of growth of the fruits both in respect to the numbers harvested and total

weight. It also shows when the differences occurred and their magnitude. The number and weight of the fruit is set down opposite the date on which each picking was made and in this way the fruiting habit of each treatment is pictured. This set of graphs is characteristic of the effects secured with all of the mulching materials studied and is the only one included with this report in order to conserve space.

TABLE II—The Effect of Manure Mulching Upon the Growth of Fall Tomatoes in the Greenhouse

Treatment	Total No. Fruits	Total Wt. Lbs. per Plot	Av. Wt. Lbs. Fruit per Plant	Av. Wt. Oz. per Fruit	No. Fruits per Plant	No. 1 Fruits		Gain or Loss by Treatment per Plant
						Per cent	Wt.	
Mulched....	542	128.5	2.14	3.79	9	63.1	76.4	—0.45
Unmulched.	623	155.4	2.59	3.99	10	71.6	80.1	

Analysis of the yield records show that mulching the fall crop of tomatoes reduces the size of the fruits, the total number set, the

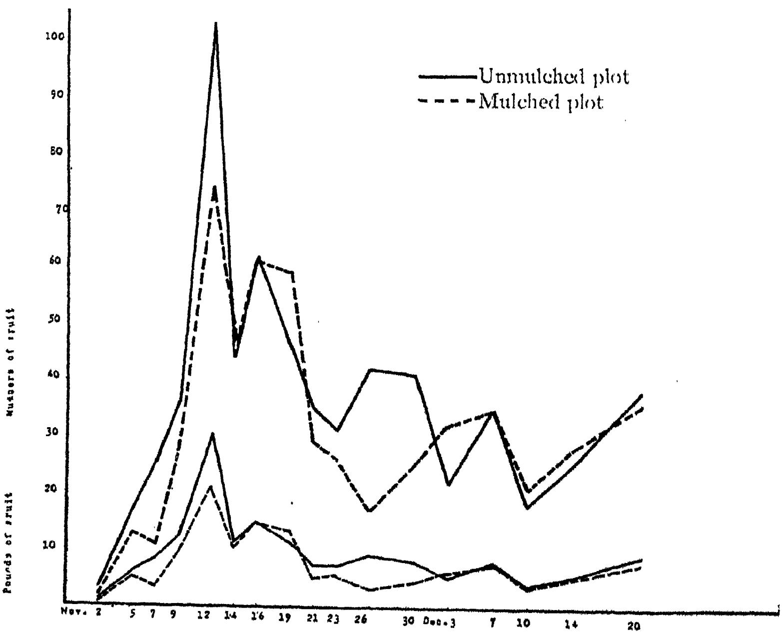


FIG. 1 The effect of manure upon fall tomatoes in the greenhouse.

weight produced, the number of fruits matured per plant, and the percentages of grade Number 1 fruits. The loss is nearly ½ pound per plant due to the mulching applied. The behavior of the spring crop appeared to be about the same as the one just described, and if the plants in the spring crop had not been stopped it is thought from their general behavior that none of the mulched beds would have equaled the checks in yield.

Discussion

Soil biologists have found similar results with mulches under field conditions with various crops. Dr. Firman E. Bear of Ohio State University, reported a reduction in yield in tomatoes under field conditions following an application of 16 tons per acre of fresh strawy manure as a top dressing. The writer working with fertilizers on sweet corn for canning purposes in Indiana while at Purdue University found retarded growth of the stalks accompanied by "firing" of the leaves nearly to the ear and reduced yields following the application of only 10 tons per acre of fresh barnyard manure as a top dressing just before planting. This condition occurred upon the rich black prairie loams as well as the lighter colored clays of central Indiana.

Biologists explain this condition by saying that the bacteria within the soil use up the nitrogen of the mulch as well as of the soil to form protein for their own growth while breaking down the carbohydrate materials within the mulch. Since they are more efficient nitrogen gatherers than the plants they appropriate it for their own use and the plants must starve. That it is a case of nitrogen starvation in the greenhouse has been repeatedly shown by the writer by applying nitrate of soda or sulphate of ammonia broadcast along the rows just before watering. Within 5 or 6 days following the treatment the light yellowish-green color disappeared and the plants regained a dark normal green. They resumed growth and the fruits swelled faster and ripened quicker than those on the unnitrated plants.

While no new theory nor new principle has been discovered by these investigations, it is of interest to know that this old established one operates so swiftly under greenhouse conditions. It is very important that greenhouse men be informed that mulching as a principle is wrong and that these investigations show as well as certain others not here reported, that many of the so-called "advantages" do not obtain when mulches have been applied. Under the conditions of these experiments the mulched plants used as much water as the unmulched. The soil was only 1 to 2° F. cooler on hot bright days in summer under the mulch than in the unmulched soil. There was no cultivating, of course, but the expense and labor of applying the mulch was high and probably would more than pay for the entire season's cultivation. There was no case found where mulching prevented packing by tramping while wet. By actual test the preparation of unmulched fertile clay soil under greenhouse conditions was prepared for the following crop just as easily as mulched soil in an adjacent bed which otherwise had been treated the same. As far as these investigations have been conducted, no evidence has been discovered that would tend to make mulching of greenhouse tomatoes a necessary or practical procedure.

The Possibilities of Sand Culture for Research and Commercial Work in Horticulture*

By W. Rei Robbins, *Experiment Station, New Brunswick, N. J.*

In the past, many different plants have been grown in sand and solution culture. Plant physiologists have done most of this work under fairly well controlled conditions of nutrient supply. Shive (7), Tottingham (9), McCall (2, 3), and others, using the triangle system, have devised and used complete series of nutrient solutions, all the solutions in the series having the same osmotic concentration, but differing from each other with respect to the proportion of the salts used by a definite percentage of the total concentration. These triangles of nutrient solutions, suitable for the growth of plants in sand culture have already been described, (1) (7) (9). The solutions have been tested and certain ones have produced plants apparently comparable in every way to individuals of the same variety grown under the best conditions of soil culture.

It is true that it may be more difficult to grow certain plants in artificial culture than in soil, because the hydrogen-ion concentration oxygen supply, renewal of the nutrient solution, and the optimum supply of iron are factors which must be considered.

The method of the growth of plants in artificial culture in quartz sand supplied with inorganic nutrient solution has not been very generally employed but holds great promise for further investigation of many horticultural problems, at present apparently not possible of solution by other experimental methods.

Several methods of growing plants in artificial culture with reference to the renewal of the nutrient solution have been used. That of constant drip, described by Shive and Stahl (8) is illustrated in Fig. 1, Plate I, which shows a series of peach seedlings in sand culture. A single culture consists of a plant in white quartz sand in a clay pot, the outside of which is waterproofed with two coats of paint. A glass tube of about one-half millimeter bore continuously siphons the nutrient solution to the sand in the pot from the reservoir which is filled daily with solution sufficient to last 24 hours and to meet the needs of the plant, usually one liter. This reservoir is an enamel pan holding two liters but may be of glass or other non-corrosive, non-porous material. Another method of renewing the nutrient solutions was used with cauliflower, tomato, and asparagus plants. These plants were grown in sand to which was added nutrient solution, the frequency of application depending upon the type of plant desired, the purpose of the experiment, and the seasonal and artificially controlled conditions of environment. The constant drip method provides better control of nutrient conditions because it

*Paper of the Journal Series, New Jersey Agricultural Experiment Station, Division of Horticulture.

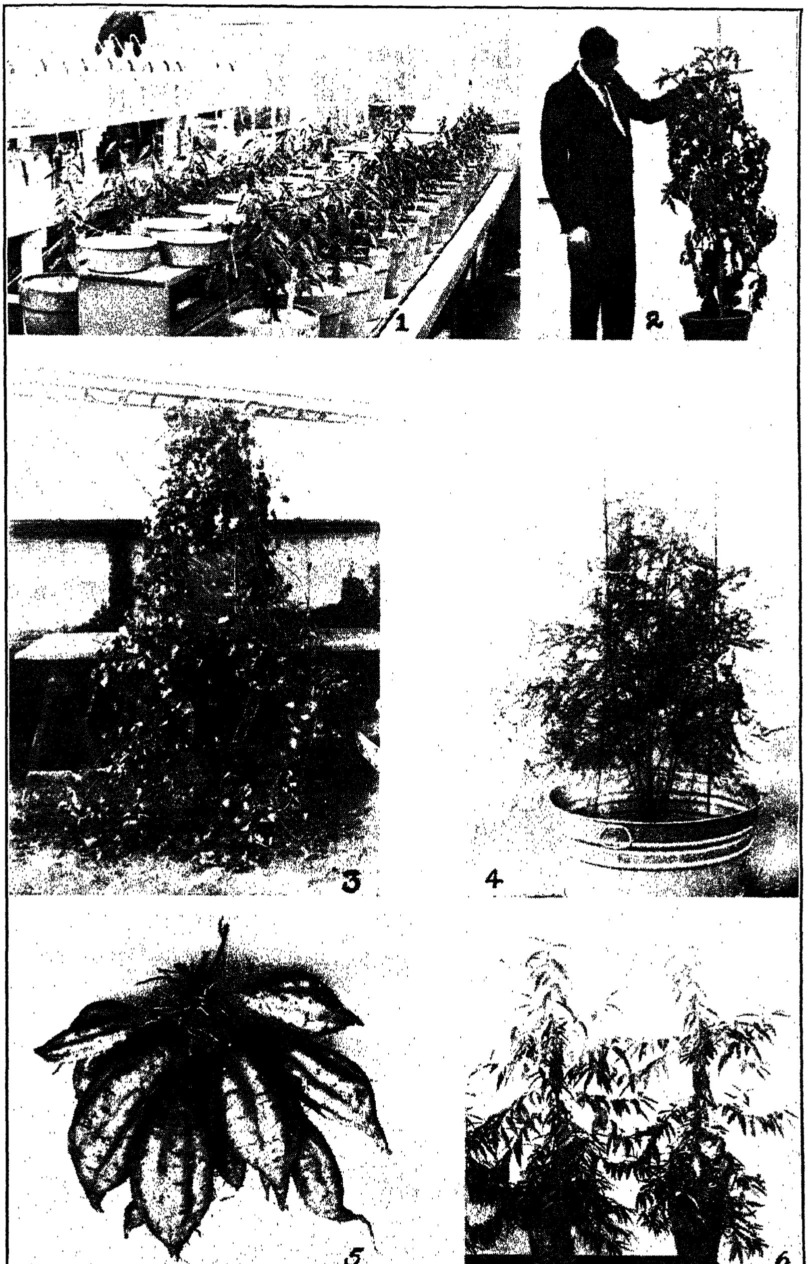


PLATE I—Plants Grown in Sand Culture

Fig. 1, a series of peach seedlings with equipment to supply nutrient solution. Fig. 2, tomato. Fig. 3, sweet potato. Fig. 4, asparagus. Fig. 5, roots of a single sweet potato plant. Fig. 6, peach seedlings.

insures a more constant proportion of the nutrient salts due to the continuous flow of fresh solution.

Three common types of important horticultural plants have been grown successfully in sand culture, namely floricultural, fruit, and vegetable plants. As representing the floricultural group, there have been grown narcissus, some results of work with which have already been reported (4), roses, and carnations, some work with the latter being described on other pages in this volume. Carnation plants grown in sand culture both in pots and in greenhouse benches were commercially more profitable than others of the same variety grown under the usual greenhouse conditions.

As representative of the fruit group, peach seedlings have been grown in sand culture, using a series of nutrient solutions as reported elsewhere in these proceedings. Fig. 1, Plate I shows the excellent growth of the plants early in the experiment. Two of these same plants are illustrated in Fig. 6 of Plate I, when at the end of 15 weeks they had reached a height of 52 inches.

Vegetable plants have been grown in sand culture with very good results. Fig. 4 shows an asparagus plant grown in one season from a one-year root. Some of the results of work with asparagus in sand culture have recently been reported (6). Cauliflower plants have been grown in sand culture in the greenhouse to study premature heading as associated with the nutrient treatment and chemical composition, some details of which are discussed in another paper in these proceedings. Fig. 2 shows a tomato plant grown in sand culture from which the size, type of plant, and crop of fruit may be estimated. Tomato plants have been grown in sand culture, (5) which reached a height of 1.8 meters. Other single plants which were grown until fruit production ceased, bore a total crop of 9.3 kgm. (20 pounds) of ripe tomatoes. The tomato plant can be grown easily in sand culture if reasonable care is taken with the type and application of the nutrient solution.

During the past three years, sweet potatoes have been grown in sand culture using the constant drip method. Fig. 3 of Plate I shows a single plant in a 14-inch clay pot with the vines so arranged as to reveal the extent of stem growth. One of the sweet potato plants in sand culture had a total length of vine of nearly 150 meters. Fig. 5 shows the roots of a sweet potato plant grown in one of these sand cultures. The root yield of this plant compares favorably with good hills in the field. The largest potato weighed nearly one-half pound and the total weight of potatoes was over 2¼ pounds.

It is hoped that this paper may encourage the more extensive use of sand culture for certain types of investigational work in horticulture. Better control of vegetative and reproductive growth of plants is obtained when as in sand culture, the nutrient supply may be modified at will as required by seasonal changes. This fact, together with the increasing difficulty and cost of obtaining composted soil and other organic matter for use in the greenhouse, commends the trial of sand culture for the commercial production of greenhouse crops.

Literature Cited

1. A plan for cooperated research on the salt requirements of representative agricultural plants, prepared for a special committee of the division of biology and agriculture of the National Research Council. Edited by B. E. Livingston, 2nd Edition. Baltimore, 1919.
2. McCall, A. G. The physiological balance of nutrient solutions for plants in sand culture. Soil Sci., 2:207–253. 1916.
3. ————. The physiological requirements of wheat and soybeans growing in sand media. Proc. Soc. Prom. Agric. Sci., 46–59. 1916.
4. Nightingale, G. T., and Robbins, W. R. Some phases of nitrogen metabolism in polyanthus narcissus. N. J. Agr. Exp. Sta. Bul. 472. 1928.
5. Nightingale, G. T., Schermerhorn, L. G., and Robbins, W. R. The growth status of the tomato as correlated with organic nitrogen and carbohydrates in roots, stems and leaves. N. J. Agr. Exp. Sta. Bul. 461. 1928.
6. Nightingale, G. T., and Schermerhorn, L. G. Nitrate assimilation by asparagus in the absence of light. N. J. Exp. Sta. Bul. 476. 1928.
7. Shive, J. W. A study of physiological balance in nutrient media. Physiol. Res., 1:327–397. 1915.
8. Shive, J. W., and Stahl, A. L. Constant rates of continuous solution renewal for plants in water cultures. Bot. Gaz., 84: No. 3. 1927.
9. Tottingham, W. E. A quantitative and physiological study of nutrient solutions for plant cultures. Physiol. Res., 1:133–245. 1914.

Cold Storage, Ripening, and Respiration Studies of the Fuerte Avocado

By E. L. OVERHOLSER, *University of California, Davis, Calif.*

THE Fuerte, which appears to be a hybrid between the Guatemalan and Mexican races is the most important variety of avocado grown in California.

Condit (1915) reported that avocados can be held at temperatures ranging from 0 to 2 degrees C. for a period of two months. Dybowski (1902) stated that with shipments of avocados from the Antilles to France, a temperature of 2 degrees C. was the most satisfactory. Higgins, Hunn and Holt (1911) determined that prolonged storage at temperatures of 0 to 2 degrees C., resulted in the blackening of the interior of avocados. Such temperatures, however, apparently could be endured without injury for three or four weeks. They recommended that the storage temperature be kept not below 4.5 degrees C. Wilcox (1914) reported that avocados may be held without injury at a temperature of 0 degrees C. for two months.

Observations by Overholser (1925) indicated that, with the exception of the Fuerte, most varieties of avocados kept best at about 4.5 degrees C. At temperatures as low as 0 degrees C., with the possible exception of the Royal, the fruit remained firm, but the epidermis and flesh, especially about the vascular bundles, turned brown in color. Furthermore, upon removal to room temperature from 0 degrees C. the fruit subsequently failed to soften, but instead wilted and blackened.

The Fuerte, when stored at 4.5 degrees C., retained the normal external appearance, but the pulp became browned, and remained in a firm unripe condition after removal to room temperatures (18 to 22 degrees C.). At a storage temperature of 7 degrees C., the fruits ripened and became sufficiently soft to indicate the approximate desirable time of removal from storage.

The observations were repeated during the season of 1928 and similar responses of the Fuerte were noted, when the fruit was harvested in a hard to firm stage of ripeness and stored with minimum delay. Depending upon the time of harvest it generally required from 5 to 7 days for the fruits to soften at room temperatures and they remained marketable for from 4 to 6 days longer. The work of three seasons indicated that at 7 degrees C. the fruit kept satisfactorily for three or four weeks. After the fruit had softened either at room temperature or 7 degrees C. it could then be satisfactorily kept for an additional three or four weeks at 0 degrees C. When fruits were stored while hard to firm in degree of maturity at 4.5 degrees C. and lower the tissue remained firm, became somewhat tough, and subsequently failed to soften satisfactorily after removal to room temperatures.

Studies were made of the respiration intensity of Fuerte avocados as measured by the carbon dioxide production, using the method described by Bennett and Bartholomew (1924). Specimens weighing from 200 to 300 grams were placed in wide mouth glass jars having about five liters capacity. These respiration chambers were closed with No. 14 rubber stoppers containing two brass stop-cocks. Quadruplicate sets were placed at: (a) room temperatures, (19.5 to 22.3 degrees C.); (b) refrigerator car temperatures (7.1 to 8.1 degrees C.) and (c) cold storage temperatures (0.0 to 0.1 degrees C.).

The average duration of the respiration period at the highest temperatures was about 30 hours; at the intermediate temperatures, 108 hours; and at the lowest temperature 165 hours. At the end of each respiration period, duplicate samples of gas from each of the jars were analyzed, by means of a modified Orsat apparatus, for carbon dioxide and oxygen content. The jars were then opened and the fruit aerated for several hours. When again sealed the fruits were surrounded by air having normal content of oxygen and carbon dioxide before the next respiration period was begun. After correcting for temperature and pressure differences the respiration intensity was computed in milligrams of carbon dioxide produced per kilogram of fruit per hour.

In Table I is shown the respiration intensity of Fuerte avocados at room temperatures. The initial respiration intensity at room temperatures was relatively high, averaging about 100 milligrams of carbon dioxide per kilogram of fruit per hour. With each succeeding respiration period, however, it dropped. After 10 periods, averaging approximately 31 hours each, it was only one-half that during the first 36 hours.

TABLE I—THE RESPIRATION INTENSITY OF FUERTE AVOCADOS AT ROOM TEMPERATURES

Average Temp. °C.	Duration Respiration Period(Hours)	Average Percent CO_2 Produced	Average Percent O_2 Left	Mgms. CO_2 Per Kilo Per Hour	Repisartion Ratio CO_2/O_2
21.5	36.0	12.8	6.6	100.1	.891
19.7	21.5	8.4	11.2	94.4	.864
21.5	25.5	8.3	9.8	77.0	.806
22.3	22.5	7.3	11.0	74.6	.729
22.0	24.7	6.9	10.3	73.2	.727
21.0	58.1	11.5	5.9	64.1	.754
22.0	24.0	6.8	11.3	67.7	.725
20.3	36.0	9.3	9.4	58.4	.777
21.0	24.5	6.3	13.0	60.1	.751
19.5	31.2	6.6	12.1	50.0	.752
Ave.21.1	31.1	8.3	10.1	72.0	.778

This drop in respiration intensity with succeeding time intervals agrees with unpublished data by Hopkins (1926) for potatoes and Hill (1913) for fruit. Since Hopkins employed the absorption method

the carbon dioxide surrounding the tubers did not increase nor the oxygen content decrease, and, therefore neither of these factors appears to account for the decline in respiration intensity.

It is recognized, however, as a result of the work of Kidd (1914) and Kidd, West and Kidd (1927) that the accumulation of carbon dioxide and decrease in oxygen surrounding the avocado from one respiration period to another probably tended to depress respiration intensity. Furthermore, its effect may have been accumulative. As a matter of fact it was observed that the specimens in the respiration chambers remained firm longer, wilted less, and appeared marketable for a longer period of time than did check specimens in open baskets.

There does not, however, appear to have been any measurable anaerobic respiration, since the respiration ratio, or the per cent of carbon dioxide produced divided by the oxygen consumed, was in every case less than unity. Nevertheless, Kidd, West and Kidd point out that at the higher temperatures oxygen deficiency rather than carbon dioxide increase is likely to be the factor in modifying respiration intensity. It is suggested that the work of Kidd, and West and Kidd might explain some of the data in this paper.

It is known that if fat or oil is the respirable substance primarily consumed, as in the avocado, the respiration ratio is less than unity. According to Liaskowki (1874) the low values are connected with the fact that the fats change over into sugars and thus their respiration is effected. In any case with the avocado more oxygen is absorbed than carbon dioxide is evolved. There may be an independent absorption of oxygen for other purposes simultaneously with the oxygen of respiration.

In Table II is shown the respiration intensity of Fuerte avocados at refrigerator car temperatures (7.0 degrees C.). The respiration

TABLE II—THE RESPIRATION INTENSITY OF FUERTE AVOCADOS AT REFRIGERATOR CAR TEMPERATURES

Average Temp. °C.	Duration Respiration Period (Hours)	Average Percent CO_2 Produced	Average Percent O_2 Left	Mgms. CO_2 per Kilo per Hour	Repsiration Intensity CO_2/O_2
7.1	70.3	5.8	13.3	21.30	0.781
7.3	85.3	6.2	13.2	19.01	0.791
7.4	141.0	9.8	8.3	18.44	0.699
7.1	109.3	7.5	10.7	18.09	0.740
7.3	120.5	8.5	9.6	18.14	0.750
7.4	111.2	7.0	11.3	17.44	0.735
8.1	117.2	9.2	8.0	22.40	0.708
Ave. 7.4	107.8	7.7	10.6	19.26	0.743

intensity at 7.1 to 8.1 degrees C. averaged less than one-third that at 19.5 to 22.3 degrees C. Furthermore, it did not decline as was the case at room temperatures. Kidd, West and Kidd reported that

temperatures averaging approximately 7.0 degrees C. were about the optimum to lessen the danger from oxygen deficiency and at the same time result in minimum toxicity from carbon dioxide increase.

The respiration ratio also averaged somewhat lower at 7.0 degrees C. than at 21 degrees C. According to Aubert (1892) in the case of succulent tissues, such as fruits, kept at low temperatures, there is an incomplete oxidation of sugar and an intake of a surplus of oxygen with the formation of organic acids. Hence, at lower temperatures the respiration ratio tends to be below unity.

TABLE III—THE RESPIRATION INTENSITY OF FUERTE AVOCADOS AT COLD STORAGE TEMPERATURES

Average Temp. °C.	Duration Respiration Period (Hours)	Average Percent CO_2 Produced	Average Percent O_2 Left	Mgms. CO_2 per Kilo per Hour	Respiration Intensity CO_2/O_2
0.0	190.0	5.6	14.0	8.8	0.795
0.0	141.0	2.7	17.1	6.0	0.700
0.1	117.5	2.5	17.7	6.4	0.759
0.0	165.7	3.2	16.7	5.8	0.757
0.0	165.5	2.5	17.5	4.0	0.668
0.0	210.5	2.1	17.6	3.2	0.583
0.1	190.0	2.0	18.0	3.3	0.600
0.0	171.0	1.1	18.8	1.8	0.474
0.0	136.0	0.9	18.6	1.9	0.366
Ave. 0.0	165.0	2.5	17.3	4.6	0.634

In Table III is shown the respiration intensity of Fuerte avocados at cold storage temperatures (0 degrees C.). While the drop of 14 degrees C. between 21 and 7 degrees C. reduced the respiration intensity to less than one-third, the further drop of only 7 degrees C. resulted in the intensity of 0 degrees C. being less than one-fourth that at 7.1 degrees C. It appeared that a comparatively small drop in temperature below 7 degrees C. was relatively more effective in retarding respiration than was a much larger drop at temperatures of 21 degrees C. Gore (1911) found for different fruits that the average temperature increase required to double the respiration activity was 8.01 degrees C. With prolonged storage at 0 degrees C. the respiration intensity became less than one-fourth that during the first period and, hence dropped to a greater extent than was the case at room temperatures. At 0 degrees C. increases in the percentages of carbon dioxide are according to Kidd, West and Kidd, more toxic than at the higher temperatures.

In agreement with Aubert, at 0 degrees C. the respiration ratio averaged less than at 7 degrees C. It also tended to become progressively lower with succeeding respiration periods and longer time at 0 degrees C. The longer the fruit remained at 0 degrees C. the larger the amounts of oxygen consumed for a given production of carbon dioxide.

Literature Cited

1. Aubert, E. Rev. Gen. de bot., 4:203. 1892.
2. Bennett, J. P., and E. T. Bartholomew. The respiration of potato tubers in relation to the occurrence of black-heart. Calif. Agr. Exp. Sta., Tech. Paper 14. 1924.
3. Condit, I. J. The avocado in California. Calif. Agr. Exp. Sta. Bul. 254, 381–402. 1915.
4. Dybowski. Traite pratique des cultures tropicales. 450. 1902.
5. Gore, H. C. Studies on fruit respiration. U. S. D. A. Bur. Chem. Bul. 142, 5–40. 1911.
6. Higgins, J. E., Hunn, C. J., and Holt, V. S. The avocado in Hawaii. Hawaii Agr. Exp. Sta. Bul. 25, 1–48. 1911.
7. Hill, George R., Jr. Respiration of fruits and growing plant tissues in certain gases. Cornell Agr. Exp. Sta. Bul. 330, 377–408. 1913.
8. Hopkins, E. F. Respiration of individual potato tubers as related to their sugar content (Unpublished). 1926.
9. Kidd, Franklin. The controlling influence of carbon dioxide in the maturation, dormancy and dormancy of seeds. Proc. Roy. Soc. B. 87, Pts. I and II, 408–652. 1914.
10. Kidd, Franklin, West, Cyril, and Kidd, M. N. Gas storage of fruit. Food Inves. Special Rept. No. 30, Dept. Sci. and Indus. Res. Great Britain, 1–87. 1927.
11. Liaskowski, N. Chemische Untersuch. uber die Keimring von Kurbissamen. 1874.
12. Overholser, E. L. Cold storage behavior of avocados. Ann. Rept., Calif. Avocados Ass'n. Los Angeles, Cal f. 32–40. 1925.
13. Wilcox, N. V. Report of Hawaii Agr. Exp. Sta. 1914.

Notes on Nutrient Treatments, Chemical Composition and Growth Responses of Carnations with Particular Reference to "Sleepiness"

By H. M. Biekart and C. H. Connors, *Experiment Station, New Brunswick, N. J.*

THE most serious blossom fault of the carnation is probably "sleepiness," a condition characterized by flowers that may not open completely, and by slightly curled petals lacking in substance and keeping quality. The vegetative growth of these plants may be normal, to external appearance, under ordinary conditions in soil, but may be soft, with wider leaves, thicker shoots, and longer internodes than is usual. The latter type of growth was typical of the plants grown in sand cultures, upon which these notes are in part based. "Sleepiness" is particularly prevalent under commercial conditions of bench culture in composted soil, during the short and often cloudy days of early- and mid-winter, but it may occur at any time during the forcing period.

Various nutrient solutions were used during 1927–28. There is evidence that magnesium and potassium are injurious when large amounts are used in the solutions. One solution, which gave satisfactory results, employs stock solutions as follows: Calcium nitrate 2127 gm.; ammonium sulfate, 1188 gm.; magnesium sulfate, 2217 gm.; and mono-basic potassium phosphate, 1227 gm.—each amount to 18 liters of water. To make the nutrient solution, the following amounts of the stock solutions are used: Calcium nitrate, 128 cc.; ammonium sulfate, 41 cc.; magnesium sulfate, 347 cc.; mono-basic potassium phosphate, 62 cc.—made up to 18 liters. The plants which are expected to develop normal flowers receive 300 cc. of this solution about once in every three weeks. This formula is only tentative, as trials are being made at the present time, by means of the triangle system, to obtain the most satisfactory ratio and concentration of nutrient salts for growing carnations in sand.

Chemical analyses of sleepy plants at various stages of development indicate that they are typically low in metabolic carbohydrates and high in organic nitrogen and nitrates, whether such plants are grown in quartz sand with a complete solution of nutrient salts or in composted soil in a greenhouse bench. Even during the part of the winter of shortest, cloudiest days, it has been possible greatly to reduce sleepiness by limiting the external nitrogen supply of plants grown in sand, while other plants likewise grown in sand, with heavy applications of nitrates, or in the bench in composted soil, have produced typically sleepy, soft, poor-keeping flowers.

To produce normal flowers during the winter, it is necessary to apply nitrates in small quantities and not too frequently, because during short, cloudy days, it has been found that nitrates usually remain in the tissue of carnation plants from four to eight weeks,

depending upon the relative size of the plant, the hours of sunlight, and the amount of cloudiness, even though there is no external supply of nitrates available during that period.

The three types of plants that were exhibited were brought in from the field on September 7th and, after washing the roots free of soil, were set in quartz sand in 8-inch pots. This is the second year that carnations have been grown successfully in sand. It seems, therefore, quite possible that carnations may be grown on a commercial scale in sand in the greenhouse bench. There would be various advantages connected with this method. The growing conditions of the plants would be under more complete control with respect to nutrients. During the period of dark, cloudy weather which so often prevails during late fall and early winter, a thorough flushing of the sand with the hose would remove an excess of nutrients and thereby avoid accumulations that would bring about abnormal growth. When the days become longer and brighter, carnation plants have been found to assimilate nitrates more rapidly, and, at the same time, maintain a sufficient carbohydrate reserve, and, therefore, more nutrients may be applied without inducing sleepiness.

It seems probable that sand might be left in the greenhouse benches for several years in succession, whereas soil should be replaced every year. Sand would require no stirring and no weeding. These features alone would be of great economic importance. In addition, the cost even of the chemically pure nutrient chemicals which have been employed for experimental work would be much less than the cost of handling composted soil, due to the small and infrequent applications of nutrients that are necessary; but, of course, for commercial work, nutrient chemicals not so pure might be utilized.

In sand, the aeration is better than in soil, a particularly pertinent fact with reference to the carnation which is very sensitive to an excess of water about the roots. It thrives with respect to both root and top development under sand culture treatment which provides ample drainage and aeration, while the leaves will quickly become yellow and mottled if an 8-inch pot in which the plant is growing in sand is set in a pan containing an inch of water, or it will exhibit a like symptom in a composted soil if the soil is too heavy and wet.

Conclusion

Carnations can be grown in sand when supplied with a nutrient solution. Carnation plants which produce sleepy flowers are typically low in metabolic carbohydrates and high in organic nitrogen and nitrates. The possibility of growing carnations commercially in sand is not remote.

What Twenty-five Years Have Wrought in American Horticulture

(Presidential Address)

By C. P. Close, *United States Department of Agriculture, Washington, D. C.*

Introduction

SINCE the American Society for Horticultural Science is now celebrating its silver anniversary, it is fitting that we review the horticultural activities of the past quarter of a century, and consider what has been wrought in America. In the time available for the preparation of this address only a part of the field could be covered, and many interesting developments will necessarily be left out.

First of all I want to express my sincere thanks and appreciation to the many friends in the colleges and experiment stations throughout the United States and Canada, and to my associates in the United States Department of Agriculture, who have so kindly given me facts and figures which appear in this address. The subject as pertaining to the United States is so vast that not as much of the remarkable developments in Canada can be included as that wonderful country deserves.

I feel particularly honored to be President of this Society on its twenty-fifth birthday. Permit me just enough egotism to be extremely proud of the part I played in helping to shape the policy and push the growth of the Society in the 20 years I was Secretary. During that time it grew from a waddling infant to a powerful giant, while I grew gray in the service. In this address I am taking advantage of the President's privilege of exceeding the limit of eight small pages of double spaced type so popular with the other 95 men on the present program.

In this address figures are necessary to register the growth and change in horticulture, so kindly bear with them if they become irksome. I wish adverbs or gestures might have been invented to express measurements of increase, but this is not understandingly possible. It must be explained that figures for 1903 are not always available, so the earliest reliable figures obtainable are used to compare with 1928 statistics.

Why Was Horticultural Growth Imperative?

Horticultural expansion was absolutely imperative because of increase in population and change in food habits of the American people. The population of the United States in 1903 was 80,174,000, in 1928 it is estimated at 119,320,000. This is an increase of more than 39 million population in twenty-five years. Winter luxuries of a few years ago such as head lettuce, bunch carrots, baby beets, spinach, new potatoes, snap beans, fresh peas, tomatoes, etc., are

now real necessities, and their production has opened up vast fields in mild fall and winter climates. This development is a real romance in horticulture. Former fruit luxuries, yes and flower and nut luxuries also, are now real necessities the year around.

The Romance of Truck Crop Migrations

One of the big events in truck crop work is the change of location and the tremendous developments in new sections. Vegetable crops are finicky and often get tired of the old home surroundings. Some of them have the lure of travel, and long for new worlds to conquer. For instance head lettuce became dissatisfied with the cramped quarters of greenhouses and eastern conditions generally, and made a spectacular dash for the bracing high altitude summer playgrounds of Colorado and Arizona, and the mild winter valleys of California. It flourished there on 90,000 acres last year. From a modest total of 17,000 acres in the United States in 1918, it has burst into a major industry of 126,000 acres worth 31½ million dollars in 1928. Carlot shipments in 1917 were 5,428, and in 1927 were 46,850.

Spinach, the dieticians' favorite bet, had aspirations for frontier pioneering. It chose the mild and balmy clime of southern Texas where sunshine spends the winter. There as much as 9,000 acres have flourished in a single county. In that Mecca of spinach it is only necessary to plow the ground, broadcast the seed, harrow it in, and hire Mexicans to gather the crop. One branch of the spinach family stayed in Old Virginia and prospered exceedingly. These two states produce about eighty per cent of the total crop of the country. The growth of this crop between 1919 and 1928 was from 15,000 to 63,000 acres, and the yield from 77,000 to 138,000 tons. The 1928 crop was worth 7½ million dollars.

Even the humble carrot had aspiration, and moved to Texas and Louisiana for tender bunch carrot production. The acreage throughout the country has doubled since 1924, and the yield this year was nearly 6½ million bushels, worth 4½ million dollars.

The tomato, latest substitute for orange juice, has not increased in total production in the last 10 years, but has changed its habitat and moved to the land of the mocking bird and the winter tourist. It has made an outstanding development as a winter and early spring crop of many thousands of acres in California, Florida, Mississippi and Texas. In Florida it is not unusual for 10,000 acres of tomatoes to be grown in a single county. Tennessee has also recently taken on a very large new tomato industry. The crop for the country this year was 1,405,000 tons worth nearly $41,000,000.

The production of cucumbers, the painless kind, has increased considerably, the newer developments being in Florida, South Carolina, Texas and Alabama. Michigan, Colorado, Indiana and Wisconsin have added much to their pickling acreage in recent years. In 1918 the total acreage was more than 76,000 and the yield 6½ million bushels. This was increased in 1928 to more than 111,000 acres, yielding 8½ million bushels worth nearly $9,000,000.

Celery crop culture is heaviest in California, Florida, New York and Michigan. In the past ten years the acreage has about doubled, being more than 26,000 with a yield of more than 7 million crates worth $14,000,000.

There has not been much increase in total acreage of cabbage, but very large new developments have occurred in Louisiana and Texas, and some increase has been made in New York and Wisconsin. The latest figures for 1928 are 136,000 acres producing 977,000 tons worth more than $23,000,000.

California, New York, North Carolina and Arizona have largely increased their plantings of table peas, and Wisconsin and New York are still leaders in growing canning peas. This crop has nearly doubled since 1918, being 267,000 acres in 1928 with a yield of 277,000 tons, valued at nearly $20,000,000.

The heavy production of snap beans for table use is in Florida and Louisiana, but there is a very large acreage in New Jersey also. In 1918 snap beans grown for both table use and canning totalled more than 33,000 acres, with a yield of 77,000 tons. In 1928 the acreage was 135,000, and the yield 147,000 tons valued at nearly $15,000,000.

The new areas of asparagus culture are in California and Georgia. For both canning and table use in 1918 the acreage throughout the country was more than 29,000, and the yield was nearly 38,000 tons. In 1928 the acreage was 95,000 and the yield more than 110,000 tons valued at nearly $14,000,000.

The big production of Burmuda and Creole onions has taken place in Louisiana, Texas, Arkansas, Colorado and California. The growth in Valencia onion culture has occurred in Colorado, Utah and Washington. The general run of onion production has not changed much in recent years. In Texas the growing of onion plants of Burmuda and Creole onions is a very large industry producing hundreds of millions of plants annually which are shipped to points throughout this country and to some sections abroad.

There has been an enormous development in sweet potato production throughout all of the southern states. New methods of curing and storing sweet potatoes are accountable for much of the growth in sweet potato culture. The production in 1928 was 77,661,000 bushels from 810,000 acres, the crop being worth 72½ million dollars.

Pepper culture has increased considerably in New Jersey, Florida, Georgia, Louisiana and California.

Georgia, Florida, South Carolina, Texas and Missouri have gone heavily into the growing of watermelons. In ten years the acreage has increased from 81,000 to 210,000 and the production from 29,000 to 61,000 cars.

The increase in cantaloupe culture has been in California, Arizona and Colorado. The total acreage has doubled since 1918, being now more than 100,000 and the crop this year was 15,500,000 crates, worth $20,000,000.

The potato has become a real wanderer over this country. It has recently homesteaded new sections in the North, West and South. The crop of this year was simply stupendous, nearly 463 million bushels, and should be mentioned with bated breath because of the disaster it caused. The big points of present production are Aroostoc County in Maine; Greenville section in Michigan; Long Island in New York; eastern shore of Maryland and Virginia and around Norfolk, Virginia; Kaw Valley in Kansas; Orrick district in Missouri; Kearney section in Nebraska; Hollandale in Minnesota; Red River Valley in Minnesota and North Dakota; Waupaca section in Wisconsin; Fort Smith district of Arkansas; Fort Gibson in Oklahoma; Idaho Falls and Burley in Idaho; Yakima Valley in Washington; Clackamas and Multnomah Counties in Oregon; around Stockton and Los Angeles in California; Eagle Lake, Wharton and Brownsville sections in Texas; Baldwin, Escambia and Mobile Counties in Alabama; La Fourche in Louisiana; Hastings in Florida; Beaufort County and Charleston district in South Carolina; and Elizabeth City in North Carolina. Potato consumption is said to be falling off in this country, but in Ireland recent figures claim 15 bushels per capita per year.

Certified Seed Potatoes

The growth and usefulness of certified seed potatoes deserve special recognition. The first seed inspection was done in 1913 or 1914. This movement spread rapidly and 21 states produced 7,127,640 bushels in 1927. The 1928 figures are not yet available. Maine alone grew more than 3¼ million bushels. Cobbler leads all varieties with a crop of more than 2¾ million bushels; Green Mountain is next with a crop of more than 1½ million bushels; Netted Gem is third with a crop of almost a million bushels.

Fruit Production Developments

Fruits have not made the sudden flights en masse to new pastures like vegetables have done, but there has been some concentration of plantings and some shifting of production. There is a real trend toward larger commercial units and less toward smaller units. The heavy peach plantings in Georgia, North Carolina and South Carolina were mostly developed since 1903. The Satsuma orange industry of the Gulf Coast is young in years. Much of the cherry plantings of Wisconsin and Michigan are of recent date. Washington, Oregon and Idaho have increased heavily in apples and pears and have also removed hundreds of acres of trees planted on unsuitable land. Southern Texas has gone heavily into citrus and the Houston section has enough figs to yield 20 million pounds in a single crop. California has developed much in citrus, stone fruits, figs, grapes and some dates. Arizona has some dates also. The Potomac Valley has increased much in apple production.

In 1909 there were more than 217 million apple trees in the United States. In 1924 this number was reduced to about 138 million trees. This is indeed a great industry that can shed 79 million trees and not miss them. The general crop over a period of years does not change

much though an occasional year gives a deficit or a surplus. The commercial crop has increased due to better orchard care and better packing and shipping facilities. The carlot shipments of 1917 were 57,084; in 1927 they were 102,517 together with 989 cars of dried apples.

Carlot shipments will give an index of the magnitude of the commercial fruit industry. These figures may be appalling but they are also interesting. They are all for 1927:—citrus 115,541 cars, grapes 82,566 cars, peaches 41,714 cars and dried peaches 471 cars, pears 18,831 cars, fresh plums and prunes 5,988 cars and dried prunes 8,847 cars, strawberries 17,891 cars, cherries 1,461 cars and mixed deciduous fruits 5,442 cars.

Carlot Fruit and Vegetable Shipping and Receiving Point Inspection

The shipping point inspection of fruits and vegetables is of recent origin. The earliest complete records available are for the fiscal year 1923–24. During that year the shipping point inspections numbered 130,959 cars. This work grew very rapidly, and in the fiscal year ending June 30, 1928, 210,832 cars were inspected.

The first year of receiving point inspection of fruits and vegetables was the fiscal year 1918–19. Inspectors were located in 51 cities throughout the country, and they inspected 14,492 cars the first year. In the year ending June 30, 1928, they inspected 32,430 cars in these same cities. This service is of immense value when disputes arise between dealer and shipper over grade or condition of car contents.

Small Fruits

The solution of the culture and the development of varieties of blueberries is outstanding. Within the past 25 years all of the work on the conditions necessary for growing blueberries in the field and the study of methods, cultivation and propagation of this fruit, have occurred. There are now several thousand acres of blueberries under cultivation in Florida, and a large propagation and even a shipping organization of the growers of the large fruited named varieties in New Jersey, the work all resulting from the research work of Dr. F. V. Coville and the commercial application of it by Miss White.

The first variety of raspberry to be grown in the South was originated by Dr. Walter Van Fleet and named for him. It was introduced by the Department of Agriculture and has been found widely adapted to southern United States and the hot interior valleys of California.

The Young dewberry was originated in 1905 and has, within the last three or four years, proved to be adapted to the southeastern United States and to the Pacific Coast. It is already replacing the Logan in California and is perhaps qur finest bramble fruit. It is also especially adapted to utilization in canning, preserving and for frozen storage.

The Latham raspberry, our hardiest variety, is very rapidly assuming leadership as a commercial variety in the eastern United States.

The Howard 17 or Premier strawberry is fast becoming the most popular variety in northeast United States, and from the Potomac and Ohio rivers north and west to the prairie regions. Ettersburg 121 is outstanding as a canning berry. The breeding work of Dr. C.C. Georgeson in Alaska has resulted in the origination of many varieties of strawberries especially suitable for Alaskan conditions.

The chromosome studies of Dr. A. E. Longley, in which he has reported on the number of chromosomes in different species of raspberries, strawberries and blackberries, have resulted in the better understanding of the possibilities and limits of breeding in berries, as well as in other fruits, and has furnished an explanation for many of the little understood results of breeding work.

The studies of Valleau on sterility in the strawberry, appeared about 10 years ago and have proven of great help to growers and breeders in understanding their problems in connection with this fruit.

The recognition and practical control of virus diseases in the raspberry, blackberry and strawberry in the past 10 years, have been of great economic importance. Especially notable work has been done by Wilcox in Ohio, Bennett in Michigan and by the State Nursery Inspection Service of Minnesota. The work of Ruggles and Winters of the Minnesota Inspection Service, in demonstrating the possibility of a thorough cleanup of virus in the Latham, has not only great practical economic advantages but also proven a stimulus to workers in other States and in other lines.

Frozen storage of strawberries and other small fruits for use in ice cream, preserving, and other purposes, has developed remarkably in the last 10 or 15 years. At the present time over $5,000,000 worth of strawberries are packed and frozen each year. The development this year is in the very extensive use of frozen strawberries for home consumption.

The pruning studies by Johnston and Loree have given a much better understanding of the basis of pruning bramble fruits. The effect of such studies already has had considerable to do with the development of better berries and will have a greater influence in the future.

Results in Fruit Breeding

Although we have many most excellent varieties of fruits, there is room for improvement and several of our members are earnestly striving to produce new varieties better than we now have. At least a partial account of what has been accomplished since 1903 will be given. The Geneva Station has grown about 83,000 seedlings of which 45,477 have fruited. Of this number there were 3,915 apples, 2,058 pears, 344 plums, 194 peaches, 9 quinces, 370 cherries, 12,496 grapes, 13,500 raspberries, 8,900 strawberries, 726 elderberries, 1,200 Prunus tomentosum, and 1,765 of currant, gooseberry and ribes crosses. Ninety of them were promising enough to name and of these there are 31 apples, 6 pears, 4 plums, 2 cherries, 1 nectarine, 17 grapes, 13 raspberries, 15 strawberries and 1 gooseberry. Forty-five out of the 90 are now on the market.

At the New Jersey Station 8,353 peach seedlings have been grown and 15 of them have been named. Two of them, at least, are of considerable commercial importance.

The Illinois Station has grown 35,000 apple seedlings, 15,000 strawberry seedlings, and 7,000 peach seedlings. Some of these are promising but none have been named.

In Maryland the Station has grown 1,073 apple seedlings and 1,368 pear seedlings. There are 15 promising apple seedlings but not any promising pear seedlings in the lot.

The Minnesota Fruit Breeding work includes about 125,200 seedlings of which 70,000 are strawberries, 18,000 apples, 10,500 plums, 5,000 each of black raspberry and red raspberry, 3,300 pears, 3,000 currants, 2,500 each of grape and gooseberry, 500 each of apricot and cherry, 400 of peach by plum, and 4,000 miscellaneous. There have been named and introduced 17 plums including plum-cherry and sand-cherry hybrids, four apples, seven strawberries, one red raspberry, one gooseberry, and two ornamentals. The Latham raspberry is the greatest contribution of Minnesota breeding work, and in that state this year 4,400,000 plants were certified free from mosaic. The sale of plants and fruit this year in Minnesota is estimated to be worth at least $400,000.

Prof. N. E. Hansen of South Dakota lists approximately 515,000 seedlings grown since 1903. The number of the different kinds follow —western sand cherry (P. besseyi) 300,000; native plums (P. americana and P. nigra) 15,000; P. pennsylvanica 500; P. padus commutata 4,500; P. virginiana 1,000; pears 55,000; wild Siberian and American crabapples 65,000; other apples 10,000; gooseberry 25,000; native black currant 10,000; Siberian black currant 3,000; buffalo berry 7,500; Ribes aureum and R. odoratum 3,000; American hazlenut 2,000; American cranberry bush 1,000; strawberry 12,500.

Macoun of Canada reports 387,676 seedlings grown since 1903. Of these there were 221,876 apples, 12,646 peaches, 5,410 pears, 4,642 plums, 2,630 cherries, 56,913 grapes, 23,805 raspberries, 2,387 currants, 4,788 gooseberries and 52,579 strawberries. Of apples 241 were named and ten introduced; of peaches, four were named and introduced; of cherries and grapes, one each was named and introduced; of strawberries 23 were named and four introduced and one gooseberry and 22 plums were named but none introduced.

In my own work in breeding summer apples out of several hundred seedlings fruited there are seven promising red ones covering the early summer apple season, but beginning to ripen three weeks ahead of Yellow Transparent. These are being tested at 30 state experiment stations.

Nursery Root Stock Work

The whole subject of fruit stocks has been given much more attention during the past 10 years than formerly. Stocks better adapted to resist pests and winter injury are being sought eagerly by commercial growers and experimenters alike. The use of blight-resistant pear stocks, particularly on the West Coast, may be mentioned as one development in this respect.

With regard to apple stocks the industry is still largely dependent on French crab seedlings. The use of seedlings grown from domestic varieties, however, has increased until a considerable proportion of the total number of apple stocks is from domestic seed of one kind or another.

With respect to cherry stocks, while mahaleb continues to be the principal stock numerically, the proportion of mazzard stocks has increased materially and a large part of these mazzard stocks are produced from domestic seed.

The vegetative propagation of stocks is also being made the subject of considerable study. Imported methods of handling cuttings and layers for quantity production are being developed.

The propagation of woody ornamental plants has received a great deal of experimental work on the part of research men as well as practical nurserymen. The volume of material now being propagated for ornamental use in this country is many times what it was 10 to 15 years ago.

Increase in Nut Production

Twenty-five years ago nut production in this country from cultivated orchards was of minor importance. Except on the Pacific coast where the Persian walnut and almond had found congenial environment, there was practically no such thing as an orchard nut industry in the United States.

The Persian walnut had been given a general tryout in the East, but without favorable results. On the Pacific coast it was planted extensively upon a seedling basis. It was at about the beginning of the last quarter century that the use of varieties became general. Cooperative marketing of walnuts was then well established, but no thought had been given to self- or inter-sterility, dehydration, cracking or nut branding. Now all of these matters are being taken into account. Cracking, however, is resorted to only for the purpose of salvaging sound parts of imperfect nuts. In 1903 the crop was 5,500 tons, in 1927 it was 42,000 tons.

Almond growing in 1903 was well established in various interior valleys of California, where there was little danger of frost after blossoming began in January. It was generally known that most varieties were self-sterile, planting was indiscriminate, and the number of varieties used appalling. Cooperative marketing had taken firm root and had become the means of placing the industry upon its feet. Considerable expansion has since taken place. The 1903 crop was 3,210 tons and the 1927 crop 12,000 tons.

Pecan orcharding upon a commercial basis began about 1903, when the first extensive orchards of modern varieties were set. Judging by the vastness of the areas affected, the amount of capital now involved, and the magnitude of present production, the pecan industry is likely to become not only the leader among domestic nuts, but one of the greatest orchard enterprises of this country. Practically all of the leadng varieties as known today were introduced before 1903. Many new ones have since appeared, but none that are yet outstanding. Self-sterility is usually not a problem. Cooper-

ative marketing of cultivated varieties with its attendant establishment of grades and standards has made great headway. Shelling is confined chiefly to wild nuts, small sized seedlings and imperfect nuts of standard varieties. As with walnuts, almonds and filberts, carrying over from one season to another of surplus nuts in cold storage has been wholly possible. Cold stored nuts do not necessarily deteriorate quickly when removed to common storage. The crop in 1903 was 3,226 tons and in 1927 it was 11,605 tons.

Filbert growing in the Pacific Northwest has recently developed rapidly. Varieties are largely self-sterile and much work was done to determine which varieties will cross pollinate satisfactorily. The filbert is being trained to standard tree form, and attains the size of medium sized apple trees. The 1927 crop totaled 60 tons.

Black walnut orcharding is bidding for favor but is still an infant. Four varieties are being widely disseminated and four score promising seedlings are being tried out.

The chestnut was almost entirely obliterated by the deadly bark disease, but there is hope that the introduction of Oriental bark disease resistant trees, may reestablish chestnut culture.

Nut breeding, especially with the almond, pecan and filbert, is making marked headway.

Expansion of Bulb Culture

In the bulb business tremendous strides have been made. Early in this quarter-century period the development of the tuberose and caladium business in North Carolina had reached such proportion that about 1918 there was an export business in tuberoses especially to European countries. This development took place with a full competition of the foreign production.

Gladiolus culture had reached such a stage of development by the time the embargo was put in effect that the shutting out of the foreign production did not cause a ripple on the surface of our very large consumption. The development of this production has been most phenomenal and extends from central Florida to Puget Sound. Overproduction has been expected for 10 years, but the acreage is still increasing. The experience in one section of Oregon is unusual but illustrative of the wonderful increase. An acreage of well under 10 last year became 300 this year and will be 1,000 next year.

Daffodils have become a sizable industry. The Paperwhite of California and Gulf Coast regions generally, is getting up to a production where the demand of pre-war days is approximately half supplied. It is developing on an American basis.

The Dutch daffodil production is increasing. It is being done, however, very largely by Holland firms who have established their nurseries on this side of the Atlantic.

Definite statistics are difficult to get. Figures will be available in all probability this year. Recent pronouncements give 31,000,000 as the number of Polyanthus narcissus planted in Florida this autumn, while 21,000,000 Dutch daffodils are said to have been planted

in the State of Washington last year. These figures are extensive enough to give a little insight into the strides being made.

The production of lilies is one of the most spectacular of the recent bulb ventures. The discovery that the Easter lily is a hardy species was a most important one, and that it and the vast majority of others can be reproduced readily from seed and by several other methods has given a great impetus to its culture. Most lilies bloom under out-of-door conditions during the second year from seed. The Easter lily has bloomed seven months from seed but generally blooms 15 to 18 months from seed. In the short space of ten years definite procedures in reproduction have been worked out experimentally and are already being employed by numerous growers. Already there have been organized two lily growers' associations with a combined membership of 150 growers in Oregon and Washington alone. The culture is carried on over a very wide range of territory,—New England, Pacific Coast, Gulf Coast, Great Lakes region and Tennessee. We have already exported one species, and foreign growers are looking to us for stocks of species which they do not succeed with.

Tulips and hyacinths are a perfectly feasible crop as shown by repeated tests and some commercial production, but foreign competition is ruinous. The culture of these can not develop as it would do if labor costs were equalized.

Ornamental Horticulture

The development of parks has been very great. In 1903 many cities of 60,000 population were without any recreational park worthy of the name and such a thing was practically unheard of in smaller places. Many towns had a public square with a few trees, possibly some grass and a tawdry band stand. The idea of an acre of park for each one hundred inhabitants had just been advanced and not over one or two cities in the country had accepted it as a desirable goal. To-day a town of 10,000 without a park of at least 20 or 30 acres, is generally recognized as not progressive. The only association of park workers in 1903 was a New England organization with a few members from other parts of the country, totaling about 40. To-day the same organization bears the name of the American Institute of Park Executives with about 400 members from all parts of the United States and Canada, from hamlets as well as large cities. The growth in park area and park interest has far exceeded even this proportion.

The playground movement as such was not really under way in 1903. A few far seeing individuals in widely separated places were beginning to sympathize with the child without a country, and a few experimental playgrounds were being tried both on school property and in parks, but not as a unit in themselves. Today the recognition of playgrounds as a community need is even greater than the recognition of the need of parks. In fact so great is it that with some people the reason for a park is synonomous with the need for a playground. The idea has developed so far that there is an association with a highly paid secretary promoting and correlating the work.

Interest in home ground planting for the masses has also developed in the past 25 years. Many estates of five acres or more in the neighborhood of metropolitan centers were well designed and attractively planted in 1903, but there was little attention given to the small home and garden cities were still air castles. The garden club movement with its resultant stimulation of gardening and the beautification of home surroundings, is another development of this period. And it is not confined to the cities and large towns as may be judged by the number of homes in the country that are being improved by at least a little planting each year through the efforts of the agents of the agricultural extension service. There were 89,000 of these in 1927 and they are part of a continuing program that began in a feeble way in 1916 but was not actively launched until 1919.

The past 25 years have also witnessed an increase in the number of kinds of plants available for ornamental planting, both by the introduction of new plants from abroad, and also by the breeding of new varieties. There has also been an increase in the appreciation of our native plants for American use, some of which have been brought into cultivation without being first accepted and grown by European gardeners, before being considered worthy of American planting.

In addition to this there is a wider use of the plants that were previously available and keener appreciation of the less common types of plants. The use of evergreens, especially cone-bearing trees, has been very marked and more recently the broad-leaf evergreens have been given more nearly the attention they deserve especially south of the Ohio and Potomac Rivers where they are particularly desirable.

It is difficult to measure the amount of this increase of appreciation. One indication of it is the change in the character of the business of many of the older nursery firms. Some of these were growing large amounts of fruit trees 25 years ago and others practically nothing else, while at the present time a major portion of the business is with ornamentals, the tendency being for the growing of ornamental nursery stock to increase more rapidly than the growing of fruit plants.

The florists' industry has grown by leaps and bounds in the last quarter of a century. When we see the immense amount of cut flowers that are sold every week it is hard to realize that this business began in this country only about 100 years ago. The 1900 census gives the amount of glass structures in the country as 96 million square feet and of this the florists used 68 million square feet. In 1920 the total area of glass was 162 million square feet and the returns from it were 15 million dollars for vegetables and 61 million dollars for flowers. There was almost a doubling of the area under glass in the period considered by this review.

Spraying and Spray Machinery

During the past 25 years there have been some remarkable developments in spray mixtures and spray machinery. Some of the most important discoveries in fungicides of this period are self boiled lime sulphur, dry mix lime sulphur and atomic sulphur, the control of

bitter rot of apples by bordeaux mixture, the development of paste and dry bordeaux mixture, the control of little peach by eradication of trees, the control of bacteriosis on peach leaves and fruit by zinc sulphate, and the use of oiled wrappers or shredded oiled paper to control apple scald.

In the control of insects some of the important developments are dry arsenate of lead, the use of lime sulphur for San Jose scale control in the East, paradichlorobenzine to control the peach borer, lubricating oil emulsion for insect control, magnesium arsenate for the Mexican beetle, codling moth bands treated to kill the larvae which hibernate beneath them, fluosilicates and calcium arsenate to control truck crop insects, calcium cyanamide for making hydrocyanic acid gas for greenhouse use, and hydrated lime and nicotine to make a dust spray for aphids.

Dust spraying has been developed by the manufacture of better dusting equipment and of finer spraying preparations. Much difference of opinion still exists as to the efficiency of this type of spray, but it is generally accepted to control peach rot and in some sections has been successful as a general spray for all classes of tree fruits.

There has been a remarkable development in kind and type of power spray machinery. The powerful modern spray rigs have several times the capacity and pressure development of those in use 25 years ago. One of the most forward steps in orchard spraying is the establishing of stationary spraying outfits. Within the past few years several hundred orchards in the West have been equipped with stationary outfits and in the last year or two a number of Eastern orchards have been similarly equipped, particularly in New Jersey.

Orchard Machinery

In this period of 25 years the tractor has been developed and with special tractor machinery has revolutionized orchard culture. It is fast displacing horses and mules for orchard work.

Cover Crops

Although cover crops were much used 25 years ago there have been a few changes in the period under discussion which are at least worth mentioning. Two plants used in orchards in increasingly large amounts are alfalfa and sweet clover. In the irrigated orchards of the West where alfalfa or any of the clovers are used it has been found best not to cut the crop, but to let it grow at will during the entire year.

Orchard Fertilizer

The outstanding point in orchard fertilizing in recent years is the use of a quickly available nitrogen fertilizer. Although the extraordinary benefits resulting from the use of nitrogen applied to fruit trees very early in the season is a comparatively recent discovery, the practice has spread clear across the country. Where formerly a complete fertilizer, if any, was used, now in most cases nitrogen only is depended upon as a tree fruit fertilizer. In a good many trials a pound of nitrate of soda has produced a bushel increase in a crop of

apples. Nitrogen also assures more and plumper fruit buds, a better set of fruit, larger tree growth and usually larger fruit.

Growth in Agricultural Colleges and Experiment Stations

In order to show the growth in college and experiment station work during the past 25 years an effort was made to obtain the number of men on the horticultural staffs in the colleges in 1903, in comparison with the number in 1928. With 44 states reporting there were 101 men on the horticultural staffs in 1903, and 529 in 1928 The number of horticultural graduates in 1903 was 42, and in 1928. there were 294 receiving the B.S. degree, 2 receiving the Ph.D. degree, 4 receiving the A.M. degree and 12 receiving the M.S. degree. The number of undergraduate horticultural students in 1928 is given as 2,210. The graduate students working for masters degree number 99. Those working for Ph.D. degree number 53. Besides these there are 5 working for the M.L.A. degree. These figures show that there are now five times as many horticulturists in college and station work as there were 25 years ago. The number of graduates in that time has increased nearly sevenfold. There are also about 75,000 boys and girls getting some horticultural training in the Smith-Hughes schools throughout the country.

The approximate value of horticultural equipment of all kinds in 42 colleges in 1903 was $339,000; in 1928 the value of horticultural equipment increased to $5,444,500. It was not possible to get estimates or actual figures on the 1903 budget for all classes of horticultural work, but the total reported was $125,000. In the present college year the total budgets amount to $1,632,000.

In 1903 the value of horticultural equipment in the United States Department of Agriculture was about $150,000 and the budget $180,000. The present value of the horticultural equipment is about $5,000,000 and the budget $1,100,000. There were eight men employed in horticultural work in 1903 and 64 in 1928. The present number of lines of work is 125 under 16 project headings.

College and Experiment Station Work in Canada

The information obtained from Canada is so incomplete that it is hardly worth giving because it does not do justice to the subject. The figures obtained are as follows: In 1903 most of the branch stations were not organized and only 11 men were on the horticultural staffs of the institutions in operation. This year, there are 101 men on the horticultural staffs. No horticultural graduates are reported in 1903 and only 10 in 1928. There are now 28 undergraduates in horticulture there.

Only two institutions could estimate the value of horticultural equipment and budget in 1903, this was $26,200 for equipment and $15,100 for budget. The 1928 value of equipment is $960,500 and the budget is $314,300. This is from 7 institutions reporting

Horticultural Bulletins in State Experiment Stations

An attempt was made to compare the number of horticultural bulletins published by the experiment stations in 1904 and in 1928. In 1904 there were 89 printed on fruit growing and in 1928 there were 104. This does not show very much growth. In 1904 there were 3 bulletins printed on nut culture and in 1928 there were 7. In the vegetable work there were 19 bulletins printed in 1904 and 76 in 1928. In 1904 there were 9 bulletins printed on ornamentals and landscape work and 15 were printed in 1928.

The number of bulletins printed during any particular year will vary considerably and is not an accurate index of the amount of work accomplished. During the 25 year period there were 1,707 bulletins and circulars issued on fruits. This is an average of 67 bulletins and circulars per year during that time. In nut culture there were 68 bulletins and circulars issued, in vegetable work there were 1,054 and in ornamentals there were 169 bulletins and circulars issued in the past 25 years.

Extension Work in Horticulture

In the extension work, which has been under way but a few years, there have been 323 bulletins and circulars published on fruit growing, 17 on nut growing, 530 on vegetable growing and 69 on ornamentals. During 1928 there have been, or will be, a total of 55 bulletins and circulars on fruit growing, 4 on nut growing, 44 on vegetable growing and 26 on ornamentals. These bulletins are from 36 states reporting out of 44 with horticultural projects.

In the horticultural extension work there are 78 full time men and 18 part time men, making a total of 96. There are 44 states with extension horticultural projects and the total amount of money allotted for this work by these states is $384,616. Besides this the U. S. Department of Agriculture is putting a little more than $6,000 into this work. The States allotting the most money for horticultural extension work are New York with $26,047, Pennsylvania with $23,-580, Michigan with $23,080, Ohio with $22,620. The other States putting $10,000 or more a year into horticultural extension are California, Wisconsin, Iowa, Virginia, Louisiana, Georgia, West Virginia, New Jersey, Massachusetts, Maryland and Connecticut. The other states are spending from $400 to $10,000 per year on this line of work.

College Courses in Horticulture

In assembling information on college courses past and present, I was not able to get much for direct comparison but did find a little in the galley proof of the history of agricultural colleges in this country by Dr. A. C. True. The following items were obtained:— In 1902 most horticultural instruction began in the sophomore year and laboratory and field work were emphasized; it was recommended by the Association of Agricultural Colleges that the 180 hours assigned to horticulture be divided into 20 for plant propagation, 50 for pomology, 50 for olericulture, 50 for floriculture and 30 for landscape gardening; that the study of horticulture should begin before the

senior year so elective courses might be taken in the last two college years; that the number of required hours in nine colleges varied from none in the New York College to 266 in Massachusetts, and the hours in electives were 360 in New York, 900 in Illinois, 180 in California, 430 in Michigan, 342 in Pennsylvania, 162 in Missouri, 638 in Massachusetts, 450 in Ohio and 270 in New Hampshire.

In order to arrive at the present status of horticultural courses for comparison with 1903, the 1928 catalogs of Washington, Iowa, Michigan, Maryland, and Massachusetts were carefully examined to note the subjects now given in four year courses in horticulture. It was felt that these catalogs would give a cross-section of present day horticultural courses. It must be noted that Dr. True's figures are for hours while the following figures are for credits.

Washington has courses in pomology, floriculture and landscape gardening. Pomology has 75 credits in these 22 subjects:—horticulture 3, chemistry 14, botany 4, agricultural economy 4, landscape 2, plant propagation 2, pathology 4, bacteriology 4, pomology 3, plant physiology 4, small fruits 3, soils 3, entomology 2, fruit production 3, vegetable gardening 3, fruit problems 2, commercial fruit handling 2, marketing 3, plant breeding 3, farm management 2, horticultural literature 2, and seminar 4. There are 20 electives in this course.

Iowa has only one course in horticulture. This has 110 credits in these 25 subjects:—horticulture 5, chemistry 17, plant morphology 2, greenhouse 5, vegetable growing 3, agricultural engineering 1, plant physiology 4, soils 6, plant propagation 3, landscape 2, machinery 2, fruits 4, flowers 3, botany 4, fertilizers 3, orcharding 9, genetics 4, entomology 4, agricultural economics 6, bacteriology 5, pathology 4, accounting 3, history of horticulture 3, problems 6 and seminar 2.

Michigan has courses in pomology, vegetable gardening and landscape gardening. The first two years of these courses are the same. There are 97 required credits in 19 subjects and no electives in pomology. The subjects in pomology follow:—botany 8, chemistry 20, fruit growing 2, landscape 6, surveying 3, bacteriology 4, soils 2, general horticulture 4, geology 3, agricultural engineering 2, zoology 4, plant physiology 4, landscape design 2, agricultural economics 4, pomology 13, fruit handling 3, problems 9, plant propagation 2 and small fruits 2.

Massachusetts has courses in pomology, vegetable gardening, landscape gardening and floriculture. The course in pomology has 116 required credits in these nine subjects:—chemistry 12, botany 8, entomology 7, horticulture 28, drawing 7, agricultural economics 15, landscape 4, pomology 27 and horticultural manufactures 10.

Maryland has courses in pomology, olericulture, floriculture and landscape gardening. The first two years of pomology and olericulture are alike, the other courses differ from these. There are 72 credits in pomology in these 21 subjects:—chemistry 15, zoology 4, botany 4, vegetable culture 3, geology 3, soil management 3, pomology 6, small fruits 2, fruit and vegetable judging 2, plant physi-

ology 4, floriculture 2, plant pathology 3, entomology 3, genetics 3, fruit growing 3, economics of the world 2, seminar 1, landscape 2, farm management 4, plant breeding 1 and research 2.

Research Projects in Horticulture

It was not possible to get a list of the research projects in horticulture for 1903. At about that time the Adams Bill went into effect and research work developed very fast. A list of the 1927 projects will be interesting. The total number of horticultural projects in all of the experiment stations in 1927 was 1,960. These are divided up as follows and all are directed at horticulture, although part of the work is done by pathologists, entomologists and others:—73 in agricultural economics on cost of production, marketing, and farm management; 196 in economic entomology of truck crops, fruits, nuts, ornamentals and greenhouse plants; 156 in field crops of potatoes, artichokes, melons, etc; 119 in breeding work of fruits and vegetables; 23 in pollination studies; 326 in variety tests; 233 in culture of fruits, nuts and ornamentals; 185 in fertilizer work; 71 in pruning; 7 in fruit thinning; 34 in physiology and nutrition; 15 in hardiness; 22 in fruit bud formation; 70 in propagation; 43 in harvesting, storage and transportation; 320 in pathology of horticultural crops; 9 in maturity of fruits and vegetables; and 32 miscellaneous.

Influencing Points of Progress

In reply to a question as to what particular points have had the most influence in the progress of horticulture in 25 years a great number of replies were received from members of the Society. It would be well to discuss many of these but time forbids so they will be listed only:—

Better understanding of plant physiology.
General improvement in horticultural practices.
Centralization of production passing from the general farm owner into the hands of specialists.
Quickly available nitrogenous fertilizers for orchard crops.
Greater emphasis upon research and better training in basic sciences.
Application of the principle of genetics.
Better methods of cultivation and fertilization.
Improved varieties.
Cooperative marketing, nutritional studies, scientific plant breeding, development of highly trained technical research men.
Development of relating fields in fundamental sciences, principally physiology, genetics, cytology and biochemistry.
Great increase in transportation.
More thorough control of the limiting factors such as soils and climatic conditions.
Plant nutrition and genetics.
The acquisition of better libraries, buildings and work equipment.
Statistical methods of measuring results.
Carbohydrate-nitrogen ratio.

The effect of shade on plant response.
Effect of length of day on plant maturity.
Lighter pruning.
Pollination studies.
Fruit spur studies.
Bacteriological and fermentation studies.
Fruit respiration, storage and transportation studies.
Orchard heating for citrus and deciduous fruits.
Fruit pressure tests.
Rest period and dormancy studies.
H-ion studies.
Central packing houses.
Transportation improvement, especially through the use of auto trucks.
Development of cold and common storage.
Development of refrigeration, including pre-cooling and warehousing of perishable fruits.
Improved methods of disease and insect control.
Better understanding of the physiology of growth, and its influence on pruning, fruit setting, fruit thinning, and other practices and phenomenon.
Development of spraying machinery and chemicals.
Investigation of fruit tree hardiness.
Use of ethylene gas in coloring citrus fruits and in blanching certain vegetables.
Improving packing and marketing practices.
Development of by-products industries.
Development of teaching and extension work.
Life history studies of insects and diseases, and their relation to precision in spraying.
Development in spraying materials, including proprietary mixtures.
Horticultural manufacturers, including fruit juices, canning, preserving, etc.
Stimulating effect of the American Society for Horticultural Science.

Conclusion

Although this address is long it could not cover all phases of the tremendous horticultural developments since our Society was organized 25 years ago. What will be accomplished in the next 25 years staggers the imagination with the radio, the vitaphone, the wireless telephone, the airplane, and unborn inventions, placed at our command. The Lord forbid, but we may have air trucks and ether tubes to shoot our crops through the air to market, and individual air scooters to scoot our men high in air from college to orchard and back. By 1953 it may not be necessary to gather into audiences to hear our speakers, but rather to sit comfortably at home while the President introduces the speakers from their homes. A spirited discussion then would indeed be a real scream.

For the immediate present, provision should be made for "long winded" Presidents with subjects too big to cover at one meeting. It might be well to extend the term of office so the President's address could be given in annual installments, until it and the audience are exhausted. This suggestion is passed on to the next administration. But seriously now I congratulate the Society upon its remarkable growth, its high grade of accomplishments, its congenial fellowship, its reliable leadership, and wish for it all of these and many other good things multiplied ten-fold in the years to come.

Obituary

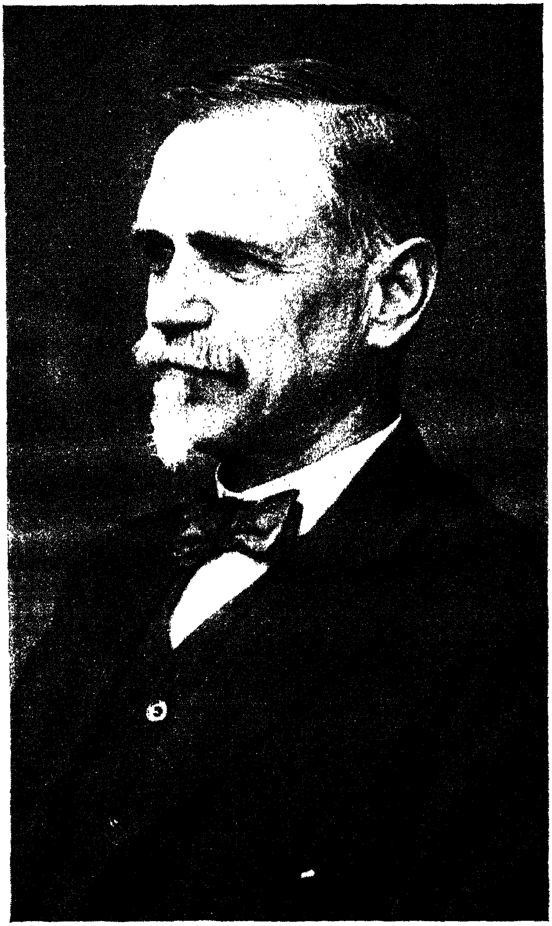
Clarence Wentworth Mathews

Clarence Wentworth Mathews died at his home in Lexingto
Kentucky, August 26th, 1928. He was born in Lawrence, Massa
chusetts, in 1861. After graduation at Cornell University in 189
he came to the University of Kentucky as Head of the Departme
of Botany, Horticulture, and Agriculture. In 1908 when the Colleg
of Agriculture was established he became Dean of the College an
Head of the Department of Botany and Horticulture. He served i
this capacity until 1911. At this time he retired as Dean of th
College to devote his attention to the direction of the rapidly growin
enrollment in Botany and Horticulture. In 1913 he became Head c
the newly organized Department of Horticulture, fulfilling his lif
long ambition. At this time he established the horticultural work c
the Experiment Station, and in 1918 Horticultural Extension worl
was added to his department. During his 36 years of service he le
the horticultural development of Kentucky and was widely know
and beloved by hosts of fruit growers and horticulturists from al
parts of the country.

From the beginning he took a prominent part in the affairs of th
University, and lived to see its development from a small strugglin
institution to its present attainment as a State University of recog-
nized standing. He contributed much to the Kentucky Stat
Horticultural Society and served as its Secretary for a number o
years. He was affiliated with a number of scientific societies an
educational associations and ever active in the affairs of his com-
munity. For a number of years he served on the Lexington Boar
of Education. In 1891 he was elected to Sigma Xi and was instru-
mental in the establishment of the Kentucky Chapter at the Uni-
versity of Kentucky.

His kindly manner and generous personality endeared him to his
associates. We mourn the loss of a true friend and a tireless worker.

A. J. Olney



C. W. MATHEWS

J. T. ROSA, Jr.

Obituary

Joseph Tooker Rosa, Jr.

Dr. J. T. Rosa, Associate Professor of Truck Crops at the University of California, Davis, California, died of infantile paralysis on August 8, 1928.

Dr. Rosa was born in Waverly Mills, South Carolina, on July 16, 1895. He received his early education in the schools of his native state and graduated from the University of South Carolina in 1915. In 1915–16 he was Instructor in Truck Crops at the Iowa State College, Ames, Iowa, receiving the degree of Master of Science there in 1916. The following year was spent at the Virginia Truck Experiment Station, Norfolk, Virginia. From 1917 to 1922 he was Assistant Professor of Horticulture at the University of Missouri, having charge of vegetable work. He received the degree of Doctor of Philosophy from the University of Missouri in the spring of 1922. In October, 1922 he was appointed Assistant Professor of Truck Crops at the University of California.

Although only a young man at the time of his death, Dr. Rosa was without question one of the leaders in his field of work. He was a prodigious worker. He could usually be found in the field or in the laboratory from early in the morning until late at night. His research efforts in California were centered mainly on a few crops, tomatoes, potatoes, spinach, and melons. The results of this work have been discussed in a number of his publications.

He early won the confidence of the growers in California and aided in the solution of many of their problems. His students admired him greatly. He demanded much of them but gave them much in return. His untimely death has been a great loss to American horticulture.

H. A. Jones

MEMBERSHIP ROLL FOR 1928

ABBOTT, C. E. . . . . University of Florida, Gainesville, Fla.
ACHER, T. B. . . . . 219 Linden Ave., Ithaca, N. Y.
ADRIANCE, G. W. . . . . A. & M. College of Texas, College Station, Tex.
ALDERMAN, W. H. . . . . . . University Farm, St. Paul, Minn.
ALLEN, F. W. . . . . University Farm, Davis, Calif.
ANDERSON, L. C. . . . . Hudson, N. Y.
ANTHONY, R. D. . . . . Experiment Station, State College, Pa.
ASAMI, Y. . . . . Tokyo Imperial University, Komaba near Tokyo, Japan
AUCHTER, E. C. . . . . University of Maryland, College Park, Md.
AUSTIN, LLOYD . . . . 60 Bedford Ave., Placerville, Calif.

BABB, M. F. . . . . University of Maine, Orono, Me.
BAILEY, J. S. . . . . Agricultural College, Amherst, Mass.
BAILEY, L. H. . . . . Ithaca, N. Y.
BAIRD, W. P. . . . . Northern Great Plains Field Station, Mandan, N. D.
BARNETT, R. J. . . . . Agricultural College, Manhattan, Kans.
BARRON, LEONARD. . . . . Garden City, N. Y.
BARSS, A. F. . . . . University of British Columbia, Vancouver, B. C.
BATCHELOR, L. D. . . . . . . University of California, Riverside, Calif.
BEACH, F. H. . . . . Ohio State University, Columbus, Ohio
BEAL, A. C. . . . . Cornell University, Ithaca, N. Y.
BEATTIE, J. H. . . . . U. S. Dept. Agr., Washington, D. C.
BEATTIE, W. R. . . . . U. S. Dept. Agr., Washington, D. C.
BEAUMONT, J. H. . . . . . . College of Agriculture, Raleigh, N. C.
BENNETT, H. B. . . . . Rosebank, Ebley, Stroud, Gloustershire, England
BENNETT, J. P. . . . . University of California, Berkeley, Calif.
BIERBAUM, A. E. . . . . University of Missouri, Columbia, Mo.
BIOLETTI, F. T. . . . . University of California, Berkeley, Calif.
BLACKMAN, G. H. . . . . . . University of Florida, Gainesville, Fla.
BLAIR, J. C. . . . . University of Illinois, Urbana, Ill.
BLAIR, W. S. . . . . Experiment Station, Kentville, Nova Scotia
BLAKE, M. A. . . . . Experiment Station, New Brunswick, N. J.
BOSWELL, V. R. . . . . University of Maryland, College Park, Md.
BRADBURY, DOROTHY. . . . 1420 Polk St., Topeka, Kans.
BRADFORD, F. C. . . . . Michigan State College, East Lansing, Mich.
BREGGER, J. T. . . . . Luther Burbank Exp. Farm, Sebastopol, Calif.
BRIERLEY, W. G. . . . . University Farm, St. Paul, Minn.
BRODERICK, F. W. . . . . . . Agricultural College, Winnipeg, Manitoba
BROWN, G. G. . . . . Oregon Agricultural Experiment Station, Hood River, Ore.
BROWN, H. D. . . . . Purdue University, Lafayette, Ind.
BROWN, W. S. . . . . Oregon Agricultural College, Corvallis, Ore.
BUCK, F. E. . . . . University of British Columbia, Vancouver, B. C.
BUNTING, T. G. . . . . Macdonald College, Macdonald College P. O., Quebec, Canada
BURKHOLDER, C. L. . . . . . Purdue University, Lafayette, Ind.
BURRELL, A. B. . . . . Cornell University, Ithaca, N. Y.
BURRELL, B. J. . . . . 2052 Center St., St. Paul, Minn.
BUSHNELL, J. W. . . . . Experiment Station, Wooster, Ohio

CALDEWELL, J. S. . . . . . . U. S. Dept. Agr., Washington, D. C.
CAMERON, S. H. . . . . University of California, Berkeley, Calif.
CAMP, A. F. . . . . University of Florida, Gainesville, Fla.
CARRICK, D. B. . . . . Cornell University, Ithaca, N. Y.
CHANDLER, W. H. . . . . . . University of California, Berkeley, Calif.
CHARLES, F. G. . . . . Ohio State University, Columbus, Ohio
CHITTENDEN, FRED F. . . . Royal Horticultural Gardens, Wisley, Ripley, Surrey, England.

CLARK, J. H. . . . . Experiment Station, New Brunswick, N. J.
CLARK, JR., W. S. . . . . . . University of Pennsylvania, Philadelphia, Pa.
CLOSE, C. P. . . . . U. S. Dept. Agr., Washington, D. C.
COCHRAN, G. W. . . . . Oklahoma A. & M. College, Stillwater, Okla.
COIT, J. E. . . . . 535 Prescott Street, Pasadena, Calif.
COLBY, A. S. . . . . University of Illinois, Urbana, Ill.
COLE, W. R. . . . . Agricultural College, Amherst, Mass.
COMIN, DONALD . . . . Experiment Station, Wooster, Ohio.
CONDIT, I. J. . . . . University of California, Berkeley, Calif.
CONNORS, C. H. . . . . Experiment Station, New Brunswick, N. J.
COOPER, J. R. . . . . University of Arkansas, Fayetteville, Ark.
CORBETT, L. C. . . . . U. S. Dept. Agr., Washington, D. C.
CRANE, H. L. . . . . University of West Virginia, Morgantown, W. Va.
CRIST, J. W. . . . . Agricultural College, East Lansing, Mich.
CRITTENDEN, L. W. . . . . . N. Y. State School of Agriculture, Cobleskill, N. Y.
CROSS, F. B. . . . . Oklahoma A. & M. College, Stillwater, Okla.
CULLINAN, F. P. . . . . Purdue University, Lafayette, Ind.
CUMMINGS, M. B. . . . . . . University of Vermont, Burlington, Vt.
CURRENCE, T. M. . . . . . . University Farm, St. Paul, Minn.

DALY, P. M. . . . . 263 Charlotte St., St. John, N. B.
DARROW, G. M. . . . . U. S. Dept. Agr., Washington, D. C.
DAVIS, HELEN I. . . . . Wellesley College, Wellesley, Mass.
DAVIS, M. B. . . . . Dominion Experimental Farm, Ottawa, Canada
DEAN, M. L. . . . . State Department of Agriculture, Boise, Idaho
DEARBORN, R. B. . . . . . . University of New Hampshire, Durham, N. H.
DEARING, CHARLES . . . . . Willard, N. C.
DETJEN, L. R. . . . . University of Delaware, Newark, Del.
DICKSON, G. H. . . . . Vineland Station, Ontario, Canada
DIEHL, H. A. . . . . Wenatchee, Wash.
DIKEMAN, R. C. . . . . National Farm School, Farm School, Pa.
DORNER, H. B. . . . . University of Illinois, Urbana, Ill.
DORSEY, M. J. . . . . University of Illinois, Urbana, Ill.
DRAIN, B. D. . . . . Agricultural College, Amherst, Mass.
DRINKARD, JR., A. W. . . . Experiment Station, Blacksburg, Va.
DUDLEY, F. H. . . . . 21 Parkwood Blvd., Poughkeepsie, N. Y.
DURUZ, W. P. . . . . University Farm, Davis, Calif.
DUTTON, W. C. . . . . Michigan State College, East Lansing, Mich.
DYE, A. P. . . . . University of West Virginia, Morgantown, W. Va.

ECKERSON, SOPHIA H. . . . Boyce Thompson Institute, Yonkers, N. Y.
EDMOND, J. B. . . . . Michigan State College, East Lansing, Mich.
EGUCHI, TSUNEO . . . . Osaka Ag. Exp. Sta., Sakai-Shigai, Osaka fu, Japan
EMMERT, E. M. . . . . Iowa State College, Ames, Iowa
EMSWELLER, S. L. . . . . . . University of Calfornia, Davis, Calif.
ERWIN, A. T. . . . . Iowa State College, Ames, Iowa
EVANS, R. W. . . . . Pennsylvania State College, State College, Pa.
EZELL, B. D. . . . . Box 67, Wenatchee, Wash.

FAGAN, F. N. . . . . Experiment Station, State College, Pa.
FARLEY, A. J. . . . . Rutgers College, New Brunswick, N. J.
FAROUT, F. W. . . . . Missouri Fruit Station, Mountain Grove, Mo.
FISHER, D. F. . . . . Wenatchee, Wash.
FITCH, C. L. . . . . Iowa State College, Ames, Iowa
FLEMING, HAROLD K. . . . National Farm School, Farm School, Pa.
FLEMING, W. . . . . Experiment Station, Summerland, B. C.
FLETCHER, S. W. . . . . Pennsylvania State College, State College, Pa.
FLOYD, W. L. . . . . University of Florida, Gainesville, Fla.
FRENCH, A. P. . . . . Agricultural College, Amherst, Mass.
FRIEND, W. H. . . . . Box 295, Weslaco, Texas
FROST, H. B. . . . . Citrus Experiment Station, Riverside, Calif.
FURR, J. R. . . . . Cornell University, Ithaca, N. Y.

GARDNER, F. E. . . . . University of Maryland, College Park, Md.
GARDNER, J. S. . . . . University of Kentucky, Lexington, Ky.
GARDNER, M. E. . . . . North Carolina State College, Raleigh, N. C.
GARDNER, V. R. . . . . Michigan State College, East Lansing, Mich.
GEISE, F. W. . . . . University of Maryland, College Park, Md.
GLADWIN, F. E. . . . . Experiment Station, Fredonia, N. Y.
GOULD, H. P. . . . . U. S. Dept. Agr., Washington, D. C.
GOURLEY, J. H. . . . . Experiment Station, Wooster, O.
GRAY, G. F. . . . . University of Delaware, Newark, Del.
GRAVES, G. W. . . . . Fresno State College, Fresno, Calif.
GREENE, L. . . . . Purdue University, Lafayette, Ind.
GRIFFITHS, DAVID. . . . . . U. S. Dept. Agr., Washington, D. C.
GUENGERICH, H. W. . . . . Farm Bureau, Independence, Mo.

HABER, E. S. . . . . Iowa State College, Ames, Iowa
HALLER, M. H. . . . . U. S. Dept. Agr., Washington, D. C.
HANSEN, N. E. . . . . Agricultural College, Brookings, S. D.
HARDENBURG, E. V. . . . . Cornell University, Ithaca, N. Y.
HARDY, MAX B. . . . . Experiment Station, Pullman, Wash.
HARLEY, C. P. . . . . Box 907, Wenatchee, Wash.
HARRINGTON, F. M . . . . . University of Montana, Bozeman, Mont.
HARTMAN, HENRY. . . . . . Oregon Agricultural College, Corvallis, Ore.
HARVEY, E. M. . . . . Oregon Agricultural College, Corvallis, Ore.
HAWTHORN, LESLIE R . . . Egxeriment Station, Geneva, N. Y.
HEDRICK, U. P. . . . . Experiment Station, Geneva, N. Y.
HEINICKE, A. J. . . . . Cornell University, Ithaca, N. Y.
HENDRICKSON, A. H. . . . . University Farm, Davis, Calif.
HENRICKSON, H. C. . . . . . Nox 133, San Juan, Porto Rico
HEPLER, J. R. . . . . Agricultural College, Durham, N. H.
HERRICK, R. S. . . . . State House, Des Moines, Iowa
HIGGINS, J. E. . . . . P. O. Box 383, Balboa Heights, Canal Zone
HILDRETH, A. C. . . . . Experiment Station, Orono, Me.
HIRANO, EIICHI. . . . . Tottori Agricultural College, Tottori, Japan
HOFFMANN, G. P. . . . . . . Penny Farms, Green Cove Springs, Florida
HOFFMAN, I. C. . . . . Experiment Station, Wooster, Ohio
HOFFMAN, M. B. . . . . University of West Virginia, Morgantown, W. Va.
HOFMANN, FRED W. . . . . Experiment Station, Blacksburg, Va.
HOLLAND, C. S. . . . . Ohio State University, Columbus, Ohio
HOLLISTER, S. P. . . . . Agricultural College, Storrs, Conn.
HOOKER, JR., H. D. . . . . University of Missouri, Columbia, Mo.
HOPPERT, E. H. . . . . University of Nebraska, Lincoln, Neb.
HORSFALL, FRANK. . . . . . A. and M. College, Monticello, Ark.
HOSHINO, YUZO. . . . . The Tohoku Imperial University, Sapporo, Japan
HOWARD, W. L. . . . . University Farm, Davis, Calif.
HOWE, G. H. . . . . Experiment Station, Geneva, N. Y.
HOWLETT, F. S. . . . . Exp. Station, Wooster, O.
HUELSEN, W. A. . . . . University of Illinois, Urbana, Ill.
HUFFINGTON, J. M. . . . . . Pennsylvania State College, State College, Pa.
HUSMANN, F. L. . . . . Second and Seminary Streets, Napa, Calif.
HUSMANN, G. C. . . . . U. S. Dept. Agr., Washington, D. C.

ISBELL, C. L. . . . . Alabama Polytechnic Institute, Auburn, Ala.

JACOB, H. E. . . . . University Farm, Davis, Calif.
JAMISON, F. A. . . . . A. & M. College, College Station, Texas
JENSEN, HARRY. . . . . Irrigation Branch Experiment Station, Prosser, Wash.
JOHNSON, T. C. . . . . Virginia Truck Experiment Station, Norfolk, Va.
JOHNSTON, S. M. . . . . Experiment Station, South Haven, Mich.
JONES, H. A. . . . . University Farm, Davis, Calif.

KEENE, P. L. . . . . Agricultural College, Brookings, S. D.
KELLEY, V. W. . . . . University of Illinois, Urbana, Ill.
KIMBALL, D. A. . . . . Agricultural College, Guelph, Ontario, Canada
KIMBROUGH, W. D. . . . . . Alabama Polytechnic Institute, Auburn, Ala.

KINMAN, C. F. . . . . 409 Native Sons Bldg., Sacramento, Calif.
KNOTT, J. E. . . . . Pennsylvania State College, State College, Pa.
KNOWLTON, H. E. . . . . . . West Virginia University, Morgantown, W. Va.
KOLESNICOV, V. A. . . . . . Kubansky Ag. Institute, Krasnodar, U. S. S. R.
KOTOWSKI, FELIX. . . . . . . Institute of Olericulture and Vegetable Breeding, Skierniewice, Poland
KRAUS, E. J. . . . . University of Chicago, Chicago, Ill.
KRAYBILL, H. R. . . . . Purdue University, Lafayette, Ind.

LAGASSE, F. S. . . . . University of Delaware, Newark, Del.
LANTZ, H. L. . . . . Iowa State College, Ames, Iowa
LATIMER, L. P. . . . . University of New Hampshire, Durham, N. H.
LAVOIE, J. H. . . . . Department of Agriculture, Quebec, Canada
LESLIE, W. R. . . . . Experiment Station, Morden, Manitoba
LEWIS, I. P. . . . . New Waterford, Ohio
LEWIS, MILTON T. . . . . . . Pennsylavnia State College, State College, Pa.
LIKHONOS, THEODORE. . . Institute of Applied Botany, Leningrad, Russia
LINCOLN, F. B. . . . . University of California, Berkeley, Calif.
LLOYD, J. W. . . . . University of Illinois, Urbana, Ill.
LOCKLIN, H. D. . . . . Western Washington Experiment Sta., Puyallup, Wash.
LOGAN, F. C. . . . . State Teachers' College, Cape Girardeau, Mo.
LOMBARD, P. M. . . . . U. S. Dept. Agr., Washington, D. C.
LOMMEL, W. E. . . . . Purdue University, Lafayette, Ind.
LONG, C. L. . . . . Oregon Agricultural College, Corvallis, Ore.
LOOMIS, W. E. . . . . Iowa State College, Ames, Iowa
LUCE, W. A. . . . . Wenatchee, Wash.
LUMSDEN, DAVID. . . . . . . U. S. Dept. Agr., Washington, D. C.

MACDANIELS, L. H. . . . . Cornell University, Ithaca, N. Y.
MACGILLIVRAY, J. H. . . . Purdue University, Lafayette, Ind.
MACLENNAN, A. H. . . . . . Agricultural College, Guelph, Ontario, Canada
MCCLINTOCK, J. A. . . . . . Experiment Station, Knoxville, Tenn.
MCCOLLUM, JOHN P. . . . . Cornell University, Ithaca, N. Y.
MCCORMICK, A. C. . . . . . Husum, Wash.
MCCUBBIN, E. N. . . . . . . University of West Virginia, Morgantown, W. Va.
MCCUE, C. A. . . . . Experiment Station, Newark, Del.
MCGINTY, R. A. . . . . Agricultural College, Clemson, S. C.
MCHATTON, T. H. . . . . . . State College of Agriculture, Athens, Ga.
MCKAY, H. M. . . . . College of Agriculture, Athens, Ga.
MACK, W. B. . . . . Pennsylvania State College, State College, Pa.
MACKINTOSH, R. S. . . . . . University Farm, St. Paul, Minn.
MACOUN, W. T. . . . . Central Experimental Farm, Ottawa, Canada
MAGRUDER, ROY. . . . . . . Experiment Station, Wooster, Ohio
MAGNESS, J. R. . . . . Washington State College, Pullman, Wash.
MALHOTRA, RAM CHANDAR. . University of Chicago, Chicago, Ill.
MANEY, T. J. . . . . Iowa Agricultural Experiment Station, Ames, Iowa
MARBLE, L. M. . . . . Canton, Pa.
MARSH, R. S. . . . . University of Illinois, Urbana, Ill.
MARSHALL, R. E. . . . . . . Michigan State College, East Lansing, Mich.
MASON, A. F. . . . . University of Maryland, College Park, Md.
MATTHEWS, C. D. . . . . . . College of Agriculture, Raleigh, N. C.
MATHEWS, C. W. . . . . Agricultural College, Lexington, Ky.
MEDLOCK, O. C. . . . . Alabama Polytehnic Institute, Auburn, Ala.
MERRILL, M. C. . . . . U. S. Dept. Agr., Washington, D. C.
MERRILL, SAMUEL, JR. . . 1285 Summit Ave., Pasadena, Calif.
MIKI, TAIJI. . . . . Kanagawa-ken Noji-shikenjo (Agr. Exp. Station) Ofuna, near Yokohama City, Japan
MILLER, J. C. . . . . Oklahoma A. & M. College, Stillwater, Okla.
MILLS, H. S. . . . . Box 358, Bristol, Pa.
MILWARD, J. G. . . . . University of Wisconsin, Madison, Wis.
MINNS, L. A. . . . . Cornell University, Ithaca, N. Y.
MOORE, J. G. . . . . University of Wisconsin, Madison, Wis.
MOORING, D. C. . . . . Oklahoma A. & M. College, Stillwater, Okla.

Morris, L. S. .... Brigham Young University, Provo, Utah
Morris, O. M. .... Experiment Station, Pullman, Wash.
Morrow, E. B. .... North Carolina State College, Raleigh, N. C.
Mulford, F. L. .... U. S. Dept. Agr., Washington, D. C.
Murneek, A. E. .... University of Missouri, Columbia, Mo.
Musser, A. M. .... College of Agriculture, Clemson College, S. C.
Myers, C. E. .... Experiment Station, State College, Pa.

Nagai, Keizo .... Imperial Horticultural Experiment Station, Okitsu, Shizuoka-ken, Japan
Nichols, H. E. .... Iowa State College, Ames, Iowa
Nightingale, G. F. .... Experiment Station, New Brunswick, N. J.
Nissley, C. H. .... Experiment Station, New Brunswick, N. J.
Noro, Kimijiro .... Shizuoka-ken Agricultural Experiment Station, Toyudamura, near Shizuoka, Japan

Olney, A. J. .... Experiment Station, Lexington, Ky.
Oskamp, Joseph .... Cornell University, Ithaca, N. Y.
Overholser, E. L. ..... University of California, Berkeley, Calif.
Overley, F. L. .... Wenatchee, Wash.

Paddock, W. .... Ohio State University, Columbus, Ohio
Page, E. M. .... 303 S. Seventh St., Corneli Seed Co., St. Louis, Mo.
Painter, John H. ...... Goodwell, Oklahoma
Palmer, E. F. .... Vineland Station, Ontario, Canada
Palmer, R. C. .... Experiment Station, Summerland, B. C.
Park, J. E. .... Experiment Station, Rosthern, Saskatchewan
Parker, E. R. .... Citrus Experiment Station, Riverside, Calif.
Partridge, N. L. ...... Box 133, Paw Paw, Mich.
Patterson, C. F. ...... Saskatoon, Saskatchewan, Canada
Peacock, N. D. .... University of Tennessee, Knoxville, Tenn.
Pearson, Oscar H. ..... University of California, Davis, Calif.
Pelton. W, C. .... University of Tennessee, Knoxville, Tenn.
Pentzer, W. T. .... U. S. Dept. Agr., Washington, D. C.
Peterson, Grace .... Cornell University, Ithaca, N. Y.
Philp, G. L. .... University Farm, Davis, Calif.
Pickett, B. S. .... Iowa State College, Ames, Iowa
Pickett, W. F. .... Agricultural College, Manhattan, Kans.
Potter, G. F. .... Agricultural College, Durham, N. H.
Prather, E. M. .... University of Tennessee, Knoxville, Tenn.
Presant, F. W. .... Experiment Farm, Ridgeton, Ontario, Canada
Price, H. L. .... Experiment Station,Blacksburg, Va.
Proebsting, E. L. ..... University Farm, Davis, Calif.

Quinn, J. T. .... University of Missouri, Columbia, Mo.

Raleigh, G. J. .... Botany Department, Chicago University, Chicago, Ill.
Ralston, G. S. .... Eastern Shore of Virginia Prod. Exch., Onley, Va.
Randall, G. O. .... State College of Agriculture, Raleigh, N. C.
Rasmussen, E. J. ...... University of New Hampshire, Durham, N. H.
Rawl, E. H. .... Clemson Ag. College, Clemson, S. C.
Reed, H. J. .... Experiment Station, Lafayette, Ind.
Rees, R. W. .... 256 New York Central Station, Rochester, N. Y.
Rehder, Alfred .... Arnold Arboretum, Jamaica Plain, Mass.
Reimer, F. C. .... Southern Oregon Branch Station, Talent, Ore.
Reinecke, O. S. H. .... Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, Cape Provence, South Africa
Richey, H. W. .... Iowa State College, Ames, Iowa
Robb, O. J. .... Vineland Station, Ontario, Canada
Robbins, W. Rei ...... Experiment Station, New Brunswick, N. J.
Robbins, W. W. .... University Farm, Davis, Calif.
Roberts, R. H. .... University of Wisconsin, Madison, Wis.
Robertson, W. H. ..... Department of Agriculture, Victoria, B. C.

ROLLINS, H. A. ....University of New Hampshire, Durham, N. H.
ROSA, JR., J. T. ....University Farm, Davis, Calif.
RUEF, J. U. ....Pennsylvania State College, State College, Pa.
RUGG, LEONARD ....State College Station, Fargo, N. D.
RUTH, W. A. ....University of Illinois, Urbana, Ill.

SANDSTEN, E. P. ....State Agricultural College, Fort Collins, Colo.
SAX, KARL ....University of Maine, Orono, Me.
SAYRE, C. B. ....Experiment Station, Geneva, N. Y.
SCHERMERHORN, L. C. ...Experiment Station, New Brunswick, N. J.
SCHMIDT, C. M. ....N. V. Potash Export, 19 W. 44th St., New York City
SCHNECK, H. W. ....Cornell University, Ithaca, N. Y.
SCHRADER, A. L. ....University of Maryland, College Park, Md.
SCHUSTER, C. E. ....Agricultural College, Corvallis, Ore.
SEARS, C. F. ....Agricultural College, Amherst, Mass.
SEVY, H. P. ....University of West Virginia, Morgantown, W. Va.
SHAW, J. K. ....Agricultural College, Amherst, Mass.
SHIMA, Y. ....Hokkaido Imperial University, Sapporo, Japan.
SHOEMAKER, D. N. ......U. S. Dept. Agr., Washington, D. C.
SHOEMAKER, J. S. ....Experiment Station, Wooster, Ohio
SITTON, B. G. ....Michigan State College, East Lansing, Mich.
SLATE, G. L. ....Experiment Station, Geneva, N. Y.
SMITH, EDWIN ....Grosvenor Gardens, London, SW1, England
SMITH, Ora ....2210 Haste St., Berkeley, Calif.
SNYDER, ELMER ....3930 Kerchoff Avenue, Fresno, Calif.
STAFFORD, I. B. ....Syracuse University, Syracuse, N. Y.
STANSEL, R. H. ....Substation No. 3, Angleton, Texas
STARRING, C. C. ....Montana State College of Agriculture, Bozeman, Mont.
STENE, A. E. ....Agricultural College, Kingston, R. I.
STOUT, A. B. ....New York Botanical Garden, New York City
STRONG, W. J. ....Vineland Station, Ontario, Canada
STUART, WILLIAM ....U. S. Dept. Agr., Washington, D. C.
STUCKEY, H. P. ....Experiment Station, Experiment, Ga.
SUDDS, R. H. ....Pennsylvania State College, State College, Pa.
SWEETSER, H. P. ....Cumberland Center, Maine
SWINGLE, C. F. ....U. S. Dept. Agr., Washington, D. C.

TALBERT, T. J. ....University of Missouri, Columbia, Mo.
TAWSE, W. J. ....Macdonald College, Macdonald College, Quebec, Can.
TAYLOR, R. H. ....603 Plaza Building, Sacramento, Calif.
TAYLOR, R. W. ....Alabama Polytechnic Institute, Auburn, Ala.
THAYER, D. H. ....340 E. Monte Vista Ave., Phoenix, Ariz.
THIES, W. H. ....Agricultural College, Amherst, Mass.
THOMAS, W. ....Pennsylvania State College, State College, Pa.
THOMPSON, H. C. ....Cornell University, Ithaca, N. Y.
TIEDJENS, V. A. ....240 Beaver St., Waltham, Mass.
TOENJESS, WALTER .....Michigan State College, East Lansing, Mich.
TRAUB, H. P. ....University of Minnesota, St. Paul, Minn.
TUFTS, W. P. ....University Farm, Davis, Calif.
TUCKER, L. R. ....University of Illinois, Urbana, Ill.
TUKEY, H. B. ....Experiment Station, Geneva, N. Y.
TUSSING, E. B. ....Ohio State University, Columbus, Ohio

UNDERWOOD, F. O. ......Cornell University, Ithaca, N. Y.
UPSHALL, W. H. ....Vineland Station, Ontario, Canada
URAKAWA, UNOSUKE ....Hokkaido Imperial University, Sapporo, Japan

VAN ALSTYNE, L. M. ....Experiment Station, Geneva, N. Y.
VAN ESELTINE, G. P. ....Experiment Station, Geneva, N. Y.
VAN HAARLEM, J. R. ....Vineland Station, Ontario, Canada
VAN METER, R. A. ......Agricultural College, Amherst, Mass.
VERNER, LIEF ....University of Idaho, Moscow, Idaho.
VIERHELLER, A. F. ......University of Maryland, College Park, Md.
VINSON, C. G. ....Boyce Thompson Institute, Yonkers, N. Y.

WAID, C. W. . . . . .199 East Gay Street, Columbus, Ohio
WALDO, G. F. . . . . .U. S. Dept. Agr., Washington, D. C.
WALKER, JOHN. . . . . .Experimental Farm, Indian Head, Saskatchewan
WARING, J. H. University of Maine, Orono, Me.
WATTS, R. L. . . . . .Experiment Station, State College, Pa.
WATTS, V. M. . . . . .University of Arkansas, Fayetteville, Ark.
WEBBER, H. J. . . . . .Citrus Experiment Station, Riverside, Calif.
WELLINGTON, J. W. . . . . .U. S. Dept. Agr., Washington, D. C.
WELLINGTON, R. . . . . . . .Experiment Station, Geneva, N. Y.
WELLS, H. M. . . . . .Graham Horticultural Experiment Station, Grand Rapids, Mich.
WENTWORTH, S. W. . . . . .Cornell University, Ithaca, N. Y.
WERNER, H. O. . . . . .University of Nebraska, Lincoln, Neb.
WESSELS, P. H. . . . . .Long Island Vegetable Research Farm, Riverhead, N. Y.
WESTCOURT, F. W. . . . . .College of Industrial Arts, Denton, Texas.
WESTOVER, K. C. . . . . . .West Virginia University, Morgantown, W. Va.
WHARTON, M. F. . . . . . . .University of Arizona, Tucson, Arizona
WHITEHOUSE, W. E. . . . .University of Maryland, College Park, Md.
WIGGIN, W. W. . . . . .Experiment Station, Wooster, Ohio
WIGGANS, C. C. . . . . .University of Nebraska, Lincoln, Neb.
WILCOX, A. N. . . . . .University Farm, St. Paul, Minn.
WILLIAMS, L. C. . . . . . . .Kansas Agricultural College, Manhattan, Kans.
WILSON, E. J. . . . . .Branch Station, Iowa Park, Texas
WILSON, R. M. . . . . .Experiment Station, Morden, Manitoba
WINKLER, A. J. . . . . .University Farm, Davis, Calif.
WOOD, M. N. . . . . .409 Native Sons Hall, Sacramento, Calif.
WOODBURY, C. G. . . . . . .National Canners' Association, Washington, D. C.
WOODROFF, J. G. . . . . . . .Experiment Station, Experiment, Ga.
WORK, PAUL. . . . . .Cornell University, Ithaca, N. Y.
WRIGHT, R. C. . . . . .U. S. Dept. of Agr., Washington, D. C.

YATES, H. O. . . . . .New Camden Vacational School, Merchantville, N. J.
YEAGER, A. F. . . . . .Agricultural College, Fargo, N. D.
YERGER, H. R. . . . . .2626 N. Moreland Blvd., Cleveland, Ohio
YERKES, G. E. . . . . .U. S. Dept. Agr., Washington, D. C.
YOCUM, W. W. . . . . .University of Nebraska, Lincoln, Nebraska.
YOUNG, W. J. . . . . .257 S. Tenth St., Newark, N. J.

ZIMMERLEY, H. H. . . . . . .Virginia Truck Experiment Station, Norfolk, Va.
ZIMMERMAN, P. W. . . . . .Boyce Thompson Institute, Yonkers, N. Y.

INDEX

PROCEEDINGS

of the

American Society

for

Horticultural Science

1929

26 vol

64861

TWENTY-SIXTH ANNUAL MEETING

V. R. GARDNER

PROCEEDINGS

OF THE

AMERICAN SOCIETY

FOR

HORTICULTURAL SCIENCE

1929

Twenty-Sixth Annual Meeting
DesMoines, Iowa
Dec. 30 and 31, 1929, and Jan. 1, 1930

Published by the Society
Edited by the Secretary, H. B. Tukey
Geneva, New York
February, 1930

CONTENTS

OFFICERS AND COMMITTEES FOR 1930

President...A. T. ERWIN
Vice-President....................................T. H. MCHATTON
Secretary-Treasurer..................................H. B. TUKEY
Assistant Secretary.................................F. S. HOWLETT

EXECUTIVE COMMITTEE

V. R. GARDNER, *Chairman*
F. W. BRODRICK
A. T. ERWIN, *President, ex-officio*
H. B. TUKEY, *Secretary, ex-officio*
J. A. MCCLINTOCK

NOMINATING COMMITTEE

V. R. BOSWELL, *Chairman*
R. D. ANTHONY
J. H. BEAUMONT
M. B. DAVIS
H. P. TRAUB

PROGRAM COMMITTEE

L. H. MACDANIELS, *Chairman*
J. E. KNOTT
H. B. TUKEY

SECTIONAL GROUPS AND MEMBERSHIP

C. L. ISBELL, *Chairman*
C. F. PATTERSON
K. A. RYERSON
W. P. TUFTS
A. C. HILDRETH
A. S. COLBY

BOTANICAL AND BIOLOGICAL ABSTRACTS

F. C. BRADFORD
J. W. BUSHNELL

A. A. A. S. COUNCIL

W. H. ALDERMAN

NATIONAL RESEARCH COUNCIL

E. C. AUCHTER

EDITORIAL COMMITTEE

H. A. JONES (1930)
F. C. BRADFORD (1931)
V. R. BOSWELL (1932)
J. R. MAGNESS (1933)
J. H. GOURLEY (1934)

CONSTITUTION*

ARTICLE I

The name of this Association shall be the American Society for Horticultural Science.

ARTICLE II

The object of the Society shall be to promote the Science of Horticulture.

ARTICLE III

Any person who has a baccalaureate degree and holds an official position in an agricultural college, experiment station, or Federal or state department of agriculture in the United States or Canada, is eligible to membership. Other applicants may be admitted by vote of the executive committee.

ARTICLE IV

Meetings shall be held annually at such time and place as may be designated by the Executive Committee, unless otherwise ordered by the Society.

ARTICLE V

The officers shall consist of a President, a Vice-President, and a Secretary-Treasurer, who, together with the chairman of the standing committees, shall constitute a Council to act upon all applications for membership. There shall also be an Assistant Secretary. These officers shall be elected annually by ballot.

ARTICLE VI

This Constitution may be amended by two-thirds votes of the Society at any regular meeting, notice of such amendment having been read at the last regular meeting.

BY-LAWS

SECTION 1. The President and other officers shall perform the usual duties of their respective offices. The President shall also deliver an address at each regular meeting.

SEC. 2. There shall be a Committee on Nominations consisting of five (5) members, who shall be nominated and elected by ballot at each regular meeting of the Society. It shall be the duty of this committee, at the following meeting, to suggest to the Society names for officers, referees, and members of committees for the ensuing year.†

SEC. 3. There shall be an Executive Committee, consisting of three (3) members and the President and the Secretary, ex-officio. This committee shall perform the usual duties devolving upon such committee.

SEC. 4. The Committee on Nominations shall nominate referees and alternates upon special subjects of investigation or instruction, which may be referred to its consideration by the Society. The duties of these referees shall be to make concise reports upon recent investigations or methods of teaching in the subjects assigned them and to report the present status of the same.

SEC. 5. There shall be a Committee on Program, consisting of three (3) members, of which the Secretary shall be one. This committee shall have charge of the scientific activities of the Society, except as otherwise ordered by the Society.

SEC. 6. The annual dues of the Society shall be three dollars and fifty cents.

SEC. 7. Ten members of the Society shall constitute a quorum.

---

*The Constitution and By-Laws as amended from time to time.
†Since 1913 two lists of candidates have been required.

SOCIETY AFFAIRS

RESUMÉ OF THE ANNUAL MEETING AT DES MOINES, IOWA, DECEMBER 30 AND 31, 1929, AND JANUARY 1, 1930

The twenty-sixth annual meeting was in many ways the most successful that the Society has held. Attendance was sixty-two at the opening session, reaching more than a hundred at other times, and there were representatives present from Maine, New York, New Jersey, North Carolina, Ohio, Michigan, Kentucky, Tennessee, Montana, Minnesota, Colorado, Texas, California, Washington, the District of Columbia, and Canada, besides nearby States. The sessions were held at the Polk County Court House, just across the square from the Society Headquarters at the Randolph Hotel, thus adding to the convenience of those present.

The feature of the meeting was the response of authors to the personal letter sent to them requesting them to summarize their papers and to present their material clearly with the aid of charts, lantern slides, or prepared materials. And so, even though as many as fifteen papers were presented in a half-day session, there was more time for discussion than in any previous meeting of the Society in recent years. The papers had been grouped, and no discussion was permitted until all the papers dealing with a particular subject had been heard. The sessions were called promptly and were completed as called for on the program, the papers of those not present being presented in summary form. The success of the joint session with the American Society of Plant Physiologists and the one with the Potato Association of America called for similar joint sessions another year.

The next meeting will be held at Cleveland, Ohio.

DINNER AND SOCIAL EVENING

Following the procedure inaugurated a year ago, the president's address was the feature of the dinner and social evening, at which 99 were present. The excellent arrangements made by Dr. E. S. Haber for the Society, at the Hotel Savery, and the floral decorations provided by Iowa State College, added to the pleasantness of the occasion. Following the president's address, obituaries were presented for Professor A. C. Beal by Dr. L. H. MacDaniels, for Feliks Kotowski by Professor H. B. Tukey, for Dr. H. D. Hooker, Jr., by Dr. A. E. Murneek, for Mr. Fan-Chi Kung by Professor B. S. Pickett, and for Professor C. S. Crandall by Dr. W. A. Ruth.

It being New Year's Eve, tokens and noise making machinery were introduced and carried on until the Year 1930 had begun. With Professor A. T. Irwin as Toastmaster, Professor T. J. Maney arose to complain that the president's address had been stolen bodily from some of his own writings, and then proceeded to defend his statement in a manner that establishes another member of the Society as a natural merry-maker. Professor J. H. Gourley spoke effectively upon "Forced Feeding," Professor T. H. McHatton gave a thorough discussion of "Nuts," and Dr. E. C. Auchter brought a most successful meeting to a fitting conclusion with "I am an Apple Tree."

ITEMS OF BUSINESS

Reports of Various Committees

Reports were received and placed on file from the Committee on Biological Abstracts, from the Committee on the World's Horticultural Council, from the Committee on Plant Registration, from the Society Representative on the National Research Council, and from the Society Representative on the A.A.A.S. Council.

Election of Officers

In its report the nominating committee submitted the names of A. T. Erwin and Paul Work to ballot upon for the nomination of president. The ballot resulted in the nomination of A. T. Erwin. The secretary was then instructed to cast the vote of the Society in favor of the officers and committees shown on page 7 of these Proceedings.

Audit of Society Records

The auditing committee reported that it had examined the accounts of the treasurer and found them correct.

H. P. Traub
T. J. Maney
W. P. Tufts
Committee

Resolutions

The following resolutions were adopted by the Society:

Resolved, That the thanks of the Society be given to Mr. George Hamilton, Secretary of the Convention Bureau of the Des Moines Chamber of Commerce and to those who assisted him in arranging for places of meetings, use of apparatus, and other courtesies extended to the Society; to the County Officers for the use of rooms in the Court House; to Professor E. S. Haber for making arrangements for the banquet; to Professors Volz and Fairburn for floral decorations at the banquet; and to the Program Committee and Secretary for an excellent program and an unusually enjoyable social evening.

Resolved, That in view of the serious confusion that has arisen in the nomenclature of horticultural plants because of the conflicting rules of botanical nomenclature employed in North America, the American Society for Horticultural Science desires to assure the Botanical Society of America that the American Society for Horticultural Science is vitally interested in the adoption of an international code of nomenclature to which all groups of botanists will subscribe, and to urge that the Botanical Society of America bear this in mind in the appointment of delegates to the International Botanical Congress to be held in London in August, 1930.

Resolved, That because of the probability of the revision of the International Code of Botanical Nomenclature at the International Botanical Congress in London in August, 1930; and because it is the sentiment of the American Society for Horticultural Science that the Standardized Plant Names should conform to such code, it is urged that any revision and publication of "Standardized Plant Names" be delayed until the action of the International Botanical Congress of 1930 is known.

Resolved, That the Secretary be instructed to telegraph the Greetings of the Society to Professor Albert Dickens, who is ill at Alburquerque, New Mexico.

C. P. Close
A. S. Colby
Paul Work
Committee

TREASURER'S REPORT FOR 1929

Receipts

Dues collected during 1929	$1,317.50	
Reports sold during 1929	667.50	
		$1,985.00
Interest on money in Savings acc	$ 40.38	
Balance on hand Dec. 1, 1928	$1,686.19	
Total receipts		$3,711.57

Expenditures

Dec.	20	Marion Barrett, mimeographing	$ 5.00
		Marjorie Rogers, mimeographing	2.50
Jan.	2	H. B. Tukey, Society expenses to New York City (deducting N. Y. A. E. S. travel allowance of $15)	57.04
	21	W. F. Humphrey, printing (banquet tickets, programs, stationery)	54.23

Feb.	5	Postmaster, Geneva, N. Y., stamped envelopes	22.62	
	21	Stamps	10.86	
Mar.	4	W. F. Humphrey, reprints	2.00	
	18	Stamps, mailing 1928 proceedings	54.21	
	19	Stamps, mailing 1928 foreign proceedings	7.54	
	20	Secretary's fees for 1929	250.00	
Apr.	2	W. F. Humphrey, printing 1928 proceedings	1,304.77	
	2	Stamps	10.00	
June	25	Stamps	10.00	
July	16	Postmaster, Geneva, N. Y., stamped envelopes	22.12	
Sept.	17	Stamps	20.00	
		Total expenditures	$1,832.89	
		Balance on hand Dec. 1, 1929	1,878.68	
				$3,711.57

Respectfully submitted,
H. B. TUKEY, *Treasurer*

Audited and found correct,
H. P. TRAUB
T. J. MANEY
W. P. TUFTS
Committee

Pear Breeding: An Inheritance Study of *Pyrus communis* x *P. ussuriensis* Hybrid Fruits.

By H. L. LANTZ, *Iowa State College, Ames, Iowa.*

HORTICULTURAL experience throughout the upper Mississippi valley has proven repeatedly the futility of planting standard pear varieties. The more forward-looking horticulturists, loth to give up the pear, set about to find hardy pears of satisfactory quality. There were two avenues of approach, (1) importation of varieties not yet tried, and (2) breeding new varieties for the region. Many Russian pears were tried in the upper Mississippi valley from 1885 to 1910. Unfortunately, most of the Russian pears lacked hardiness in Iowa, and all of them were more or less susceptible to blight. Two of the Russians, Bezi de la Motte and Orel 15, proved hardy and measurably free from blight. These varieties have succeeded at the State Fruit Breeding Farm at Charles City, and both have produced improved progeny.

The late C. G. Patten*, Charles City, Iowa, began his work in 1866 and later did much to draw attention to the "lamentable failure" of nearly all pear varieties. In 1916 he emphasized the pear problem, stating: "I believe it is safe to assert that there has not been grown three hundred bushels of good pears, *Pyrus communis*, in all the north half of Iowa, since its settlement, and that nine-tenths of all that have been grown were the Flemish Beauty, and this pear is rarely seen of late years because of its tendency to blight. If pears are ever to be grown over this territory in the Mississippi and Missouri valley they must be originated."

Patten's work demonstrated that there were differential variations as to hardiness and also for blight resistance. Such varieties as Warner, Bezi de la Motte, Orel 15, Longworth, Fluke, and Winter Nelis have shown a marked degree of hardiness as grown at Charles City. Next in hardiness as indicated by Patten and the later work at Charles City are the Seckel, Anjou, Flemish Beauty, and Howell. Those varieties which have proved hardiest are deficient in quality, while varieties of standard quality like Seckel, Anjou, Flemish Beauty, Howell, etc., while markedly more hardy than many other varieties, are not reliably hardy in any part of Iowa.

In the early 80's Patten became actively interested in the pear breeding problem, and in 1884 secured a start with a hardy pear of oriental origin, which was later identified as *P. ussuriensis*. The original tree, now 45 years old, still stands on the State Fruit Breeding Farm and is hardy beyond any question of doubt. This *P. ussuriensis* tree is a primitive type; it bears small, gritty fruit, and sheds its leaves in August, indicating that it is perhaps of north China origin. Eventually a number of seedlings were produced which Patten regarded as natural hybrids with Seckel and Anjou. The trees have the characteristic *P. ussuriensis* habit of growth with wide angled branches. The foliage resembles *P. ussuriensis* in shape, size, and in serrations. These seedling trees differ from the original

*Patten, C. G. Trans. Ia. State Hort. Soc. Vol. 51, p. 158. 1916.

tree in that: (1) they bloom later, generally with *P. communis*, (2) the foliage matures late and hangs to the tree as late as *P. communis*, (3) they are more vigorous in growth, (4) the fruit is larger.

In 1909 a cooperative agreement between Mr. Patten, the United States Department of Agriculture, and Iowa State College provided Mr. Patten with both financial and expert assistance. In 1914 Dr. W. F. Wight of the United States Department of Agriculture assisted Mr. Patten and a number of crosses were made between the *P. ussuriensis* hybrids and Bartlett, Anjou, Flemish Beauty,Howell and Winter Nelis. The seedlings produced by this work were in the nursery row in 1917 when the Patten station was purchased by the Iowa Agricultural Experiment Station.

The following discussion deals with the inheritance of horticultural fruit characteristics such as size, form, color, flesh, quality and season. Space will not permit a detailed explanation as to the method of procedure in assembling the data. Classifications of the various characteristics have been evolved and provide a basis for comparative studies of the fruit of the various progenies.

Despite the heterozygous and unknown genetic nature of horticultural varieties of fruits, there are certainly valid reasons for an attempt to analyze progenies to determine the inheritance of horticultural characteristics. This study is presented because there are differences between the progenies which demonstrate certain facts of inheritance.

The seed parents Seckel-Sand No. 5 and the Second Seckel-Sand No. 8 were crossed in 1914 (See Table I). These seed parents were among the *P. ussuriensis* hybrids previously mentioned.

The tree of Seckel-Sand No. 5† is like ussuriensis in habit of growth and in foliage except that the foliage is deeper green and hangs to the tree until October. It blooms about midseason and is very productive. The fruit is small, roundish turbinate, and greenish yellow with red blush. The flesh is soft, gritty, juicy, sprightly subacid, medium astringent, poor in quality and late August in season.

The tree of Second Seckel Sand No. 8† is a wonderful specimen for health, vigor and foliage. The habit of growth is good and resembles that of *P. ussuriensis* as does also the foliage. The foliage hangs to the tree a month or more after the original *P. ussuriensis* tree has shed its foliage. The fruit is medium in size, broadly necked and of good pear form. The color is pale green. The flesh is very tender, soft, very juicy, medium grain, sprightly subacid and mildly astringent. The quality is poor. Season, September 15–30.

Table I records the progenies produced by crossing Seckel-Sand No. 5 with Flemish Beauty, Bartlett, Howell, and Sheldon. Seed germination averaged 44 per cent, and 70 per cent of the trees grown in the nursery were planted in the orchard in 1917–18–19. Of those planted, 60 per cent or a total of 202 seedlings have fruited and have been described.

---

†These designations were given the trees by Patten and have been retained.

TABLE I—SEED AND TREE RECORDS OF HYBRID PEAR PROGENIES

Parentage	No. of Seeds	No. Trees in Nursery	No. Trees Planted in Orchard	Fruited and Described	
				No.	Per cent
Seckel-Sand No. 5 x Flemish Beauty	307	186	138	88	64
Seckel-Sand No. 5 x Howell	390	95	72	51	71
Seckel-Sand No. 5 x Bartlett	208	100	70	35	50
Seckel-Sand No. 5 x Sheldon	180	93	54	28	52
Total	1085	474	334	202	
2nd Seckel-Sand No. 8 x Warner	112	36	33	27	82
2nd Seckel-Sand No. 8 x Bartlett	70	13	13	9	69
2nd Seckel-Sand No. 8 x Howell	70	26	22	18	82
Winter Nelis x 2nd Seckel-Sand No. 8	80	34	30	16	53
Total	332	109	98	70	

Table II shows that there are inherent differences between the progenies as to size of fruit transmitted by the four pollen parents. No seedling of Bartlett was rated larger than medium, yet the fruits produced by this progeny averaged somewhat larger than those produced by the other progenies. Sheldon, produced the smallest fruits. There was little difference in this respect between the Flemish Beauty and Howell progenies. These data show that 85.7 per cent of the Sheldon, 82.4 per cent of the Howell, 71.9 per cent of the Flemish Beauty, and 62.8 per cent of the Bartlett fruits were below medium and small. This situation seriously limits the possibility of securing new varieties of value.

Geneticists have advanced the multiple factor hypothesis to account for variation in the size of fruits. The variation in size of the fruits produced by these progenies while dominantly below medium and small in size, suggests that size of fruit is determined by a complex multiple factor situation. It is evident that the factors brought into these combinations have failed to bring together those factors which produce a satisfactory percentage of commercial sized fruits. The absence of large fruits is interesting. The Seckel Sand No. 5 seed parent doubtless carries those factors which produce a high percentage of fruits below commercial size, and it probably would produce a high percentage of small fruits regardless of the pollen parent used in combination with it.

Pear forms are classified in many ways by different descriptive pomologists. In a study of pear seedlings, it has been convenient to classify them as roundish, pyriform, turbinate, oblate. There are variations within each form type and to classify properly a form type is sometimes somewhat puzzling. The evidence as revealed by these and many other seedlings supports the assumption that trimodal inheritance operates in most pear progenies. The forms most commonly produced are the roundish, pyriform and turbinate.

TABLE II—EXTERNAL CHARACTERISTICS OF THE SEEDLING FRUITS OF *P. Ussuriensis* HYBRIDS

Size	Seckel Sand No. 5 x Flemish Beauty		Seckel Sand No. 5 x Bartlett		Seckel Sand No. 5 x Howell		Seckel Sand No. 5 x Sheldon		2nd Seckel Sand No. 8 x Howell		2nd Seckel Sand No. 8 x Warner		2nd Seckel Sand No. 8 x Bartlett		2nd Seckel Sand No. 8 x Winter Nelis	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Measure																
Large	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Above Medium	6	6.7	0	0	2	3.9	1	3.6	2	11.1	1	3.7	1	11.1	0	0
Medium	19	21.6	13	37.2	7	13.7	3	10.7	4	22.2	2	7.4	1	11.1	2	12.5
Below Medium	32	36.4	16	45.7	17	33.4	5	17.9	5	27.8	11	40.7	6	66.6	3	18.7
Small	31	35.5	6	17.1	25	49.0	19	67.8	7	38.9	13	48.2	1	11.1	11	68.8
Total	88		35		51		28		18		27		9		16	
Shape																
Roundish	33	37.5	7	20.0	12	23.5	13	46.4	4	22.2	14	51.8	2	22.2	7	43.7
Pyriform	33	37.5	14	40.0	17	33.4	3	10.7	10	55.6	3	11.1	6	66.6	7	43.7
Turbinate	21	23.9	9	25.7	18	35.3	7	25.0	4	22.2	9	29.6	1	11.1	1	6.3
Oblate	1	1.1	5	14.3	4	7.8	5	17.9	0	0	1	3.7	0	0	1	6.3
Color																
Yellow	23	26.2	6	17.1	12	25.3	5	17.9	3	16.7	13	48.2	1	11.1	4	25.0
Yellow Blushed	20	22.7	6	17.1	16	31.4	7	25.0	3	16.7	3	11.1	2	22.2	0	0
Green	2	2.3	1	2.9	0	0	3	10.7	1	5.5	0	0	0	0	5	31.2
Green Blushed	1	1.1	2	5.7	1	1.9	0	0	3	16.7	0	0	1	11.1	1	6.3
Greenish Yellow	14	15.9	5	14.3	10	19.6	4	14.3	5	27.8	8	29.6	3	33.3	5	31.2
Greenish Yellow Blushed	28	31.8	15	42.9	12	23.5	9	32.1	3	16.7	3	11.1	2	22.2	1	6.3
Russet	0	0	0	0	0	0	0	0	0	0	1	3.7	0	0	4	25.0

In some progenies a fourth type appears, namely, the oblate. Oblate forms in these crosses are apparently recessive. In these crosses, it is not possible to determine dominance of form type. In tomatoes Lindstrom‡ found that distinct fruit shapes were transmitted in hybrid generations and that "dominance in fruit shape, while existent, is far from complete. The order of dominance in this (tomato) series is, oblate, round, and ovate. Fruit shape in the tomato is apparently determined by a simpler genetic mechanism than is fruit size."

Form types behave in different ways in the different pear progenies. Roundish and pyriform types appear in approximately equal numbers in the Flemish Beauty progeny, while in the Howell progeny the roundish, pyriform and turbinate shapes appear in approximately equal numbers. In the four progenies here studied there is no evidence of complete dominance for round, pyriform or turbinate shapes. The predominant fruit shapes seem to be conditioned by the shape of the different parents.

That the $\frac{\text{polar diameter}}{\text{transverse diameter}}$ index of the parent variety is of some significance is indicated by the Bartlett and Sheldon progenies. Sheldon, which is nearly round, produced progeny fruits of which 46.4 per cent were roundish as against the progeny of Bartlett of which 20 per cent were roundish. Bartlett, a typical pyriform pear, produced progeny of which 40 per cent were pyriform, as compared with Sheldon progeny of which 10.7 per cent were pyriform. Further examination of the table reveals that the other parental phenotypes are a fair index as to what may be expected of these parents as carriers of those factors which produce the form characteristics of pears.

Colors varied from yellow to dull green and were classified as yellow, greenish yellow and green. Red or pinkish blushed fruits were not uncommon in all color types and often enhanced the attractiveness of the fruits. From 55 to 65 per cent or slightly over one-half of the fruits were more or less blushed.

The striking characteristic among these *P. ussuriensis* hybrid fruits was softness of flesh, juiciness and lack of high quality. Less than 20 per cent of the fruits were fine grained. Coarse grained flesh characterized nearly 50 per cent of the fruits, with the exception of the Bartlett progeny, in which 17.1 per cent were coarse grained. Juiciness was dominant, except in the progeny of Sheldon. Here juicy, medium and dry-fleshed pears appeared in approximately equal numbers.

The flavor of the fruits varied from sweet to sour. The dominance of mild subacid flavor in these progenies is marked. Sheldon produced a higher percentage of sweet and mild subacid fruits than did the other three parent varieties, followed in order by Bartlett, Flemish Beauty and Howell. There were various degrees of astringency in all progenies. Slightly less than half the fruits were free

‡Lindstrum, E. W. The inheritance of ovate and related shapes to tomato fruit. Jour. Ag. Res. 34: No. 10. 1927.

TABLE III—INTERNAL CHARACTERISTICS OF THE SEEDLING FRUITS OF *P. Ussuriensis* HYBRIDS

	Seckel Sand No. 5 x Flemish Beauty		Seckel Sand No. 5 x Bartlett		Seckel Sand No. 5 x Howell		Seckel Sand No. 5 x Sheldon		2nd Seckel Sand No. 8 x Howell		2nd Seckel Sand No. 8 x Warner		2nd Seckel Sand No. 8 x Bartlett		2nd Seckel Sand No. 8 x Winter Nellis	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Grain																
Fine	14	16.0	6	17.1	7	13.7	5	17.9	2	11.0	6	22.2	0	0	0	0
Medium	37	42.0	23	65.8	22	43.2	9	32.1	8	44.5	14	51.8	5	55.5	7	43.7
Coarse	37	42.0	6	17.1	22	43.2	14	50.0	8	44.5	7	26.0	4	44.4	9	56.3
Juice																
Juicy	65	74.0	30	85.7	39	76.5	10	35.7	16	88.9	19	70.4	9	100.0	8	50.0
Medium	17	19.3	5	14.3	9	17.6	10	35.7	2	11.1	8	29.6	0	0	8	50.0
Dry	6	6.7	0	0	3	5.9	8	28.6	0	0	0	0	0	0	0	0
Flavor																
Sweet	7	7.9	2	5.7	6	11.8	5	17.9	1	5.5	9	33.3	1	11.1	0	0
Mild subacid	48	54.6	22	62.9	24	47.1	22	78.5	8	44.5	17	63.0	4	44.4	8	50.0
Sprightly subacid	28	31.8	10	28.6	17	33.4	1	3.6	9	50.0	1	3.7	3	33.3	7	43.7
Sour	5	5.7	1	2.9	4	7.7	0	0	0	0	0	0	1	11.1	1	6.3
Astringency																
None	37	42.0	14	40.0	24	47.1	21	75.0	4	22.2	21	77.8	6	66.6	4	25.0
Slight	21	23.9	7	20.0	17	34.3	5	17.9	4	22.2	4	14.8	1	11.1	2	12.5
Medium	20	22.7	12	34.2	7	13.7	2	7.1	7	38.9	2	7.4	1	11.1	5	31.2
Much	10	11.4	2	5.7	3	5.9	0	0	3	16.7	0	0	1	11.1	5	31.2
Quality																
Very good	0	0	0	0	1	1.9	0	0	0	0	1	3.7	0	0	0	0
Good	4	4.5	3	8.6	1	1.9	1	3.6	0	0	6	22.2	2	22.2	0	0
Fair	18	20.5	13	37.2	13	25.5	4	14.3	4	22.2	9	33.3	6	66.6	4	25.0
Poor	66	75.0	19	54.3	36	70.6	23	82.1	14	77.8	11	40.7	1	11.1	12	75.0
Season																
August	9	10.2	5	14.3	3	5.9	2	7.1	0	0	0	0	0	0	0	0
Sept. 1–15	27	30.7	14	40.0	13	25.5	7	25.0	0	0	2	7.4	2	22.2	6	37.5
Sept. 15–30	28	31.8	9	25.7	21	41.2	6	21.5	5	27.8	13	48.2	3	33.3	6	37.5
October	24	27.3	7	20.0	14	27.4	13	46.4	13	72.2	12	44.4	4	44.4	4	25.0
Winter	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Recommendation																
Discard	84	95.5	29	82.9	44	86.3	27	96.4	17	94.5	22	81.5	7	77.7	15	93.8
Breed	3	3.4	6	17.1	7	13.7	1	3.6	1	5.5	4	14.8	2	22.2	1	6.2
Propagate	1	1.1	0	0	0	0	0	0	0	0	1	3.7	0	0	0	0

from astringency except Sheldon progeny where 75 per cent of the fruits were non-astringent.

The final test of progeny value lies in quality. All of these *P. ussuriensis* hybrids might be dismissed because of the dominance of low quality, and conversely, because of the almost entire absence of very good quality. However, there were differences between the progenies. The Bartlett progeny was slightly superior to the others in that it produced the highest percentage of good and fair quality fruits and the lowest percentage of poor quality fruits. Sheldon produced a very high percentage of poor quality fruits, contrary to phenotype expectation.

The average season of maturity of these progenies follows that of the pollen parent. For instance, the Bartlett progeny average earlier than the other three. Sheldon produced more October pears than did the other three progenies. The fruits of many of these seedling fruits, regardless of pollen parent, were of short season, often being ripe one day and gone the next. This is a characteristic of the fruit of Seckel-Sand No. 5.

Data concerning four progenies of Second Seckel Sand No. 8 are included. These data are limited but show certain interesting features of inheritance as to the size, form and quality characteristics.

Discussion: Small fruit size and poor fruit quality were dominant in four progenies of Seckel Sand No. 5. These studies indicate the value of Bartlett as a parent when its progeny is compared with those of Flemish Beauty, Howell, and Sheldon. The progenies of Flemish Beauty and Howell were similar in average size, flesh characters, quality and season. The widest variation was between the progenies of Bartlett and Sheldon.

This experiment indicates that the breeding value of the four parents is as follows: 1. Bartlett, 2. Flemish Beauty, 3. Howell, 4. Sheldon.

In these crosses oblate shape was recessive. Complete dominance of either pyriform, turbinate or roundish fruit shape was not demonstrated, but the percentage of fruits falling within a fruit shape class seemed to depend on the shape of the parent variety.

Those seedlings which produced fruits which were an improvement over the Seckel Sand No. 5 seed parent have been retained for further crossing and for inbreeding studies.

That hardy pear trees can be bred is a demonstrated fact. It is pertinent at this point to state that hardy pear trees of pure *P. communis* origin are also a demonstrated fact at the State Fruit Breeding Farm.

The Production of Table Beet Seed Under Glassine Bags

By Roy Magruder, *Experiment Station, Wooster, Ohio*

IN connection with a plant improvement project on table beets some preliminary experiments were started in 1927 in an attempt to determine the practicability of producing selfed seed under glassine bags. This paper gives the results of one year's work in the greenhouse and two year's work in the garden on this problem.

Greenhouse Experiment

Roots of the Crosby Egyptian variety were potted in 8 in. pots Feb. 15, 1927, and placed in a cool greenhouse. Most of the plants started blooming by May 1st and had finished by the first of June.

Glassine bags about 2½ inches wide and 8 inches long were used to cover single racemes of the inflorescence. The end of the raceme was pinched out to limit its growth, and several layers of absorbent cotton were wrapped tightly about the stem and the bags fastened tightly over the cotton with paper clips to prevent insects gaining access to the flowers thru cracks between the stem and bag.

Four racemes of approximately the same size, stage of development, and location on each plant were selected, bagged, and one of each treated in the following manner: (1) Disturbed or moved as little as possible, (2) Shaken at noon each day to distribute pollen within the bag. (3) Hand pollinated every second day in the afternoon by means of a fine camels hair brush, using the pollen collected in the bag, a separate brush being used for each raceme and kept in the bag, and all opened flowers being pollinated each time. (4) Hand pollinated as above but with a mixture of freshly collected pollen from 6 or more plants.

About a week after the last flower had opened the bags were removed. As soon as the seeds had ripened the racemes were removed, the total number of flower clusters counted and the clusters with one or more stimulated carpels counted and preserved for the germination test which was not made until June, 1929. An open pollinated raceme was also taken for comparison.

The detailed results of this experiment as presented in Table I show that shaking the bags increased the per cent of stimulated clusters on all of the plants (5) that set any seed under the first two treatments. Germination, however, showed that in only two cases did the stimulated clusters contain viable embryos. Since only two plants out of the twelve produced progeny by bagging without hand pollination this method would hardly seem practical in the greenhouse.

Hand pollination with pollen collected within the bag increased the percentage of stimulated flower clusters in two-thirds of the cases. The fact that a few clusters were stimulated by hand pollination on four plants that produced no seed by shaking might indicate that lack of pollination was at least partially responsible for the low percentage of stimulated clusters under bags.

TABLE I—THE EFFECT OF BAGGING AND HAND POLLINATION ON THE SET AND GERMINATION OF TABLE BEET SEED. GREENHOUSE-GROWN 1927

Plant No.	Treatment	Flower Clusters			Stimulated Clusters	
		Total No.	Stimulated No.	Stimulated Per cent	No. Planted	Germinated Per cent
1	Not shaken	70	15	21	14	78
	Shaken	76	52	68	52	77
	Selfed, hand pollinated	68	54	79	51	68
	Crossed, hand pollinated	65	61	93	61	86
	Open pollinated	105	101	96	54	88
2	Not shaken	60	0	0	0	0
	Shaken	42	0	0	0	0
	Selfed, hand pollinated	62	17	27	17	17
	Crossed, hand pollinated	56	51	91	51	98
	Open pollinated	184	181	98	50	64
4	Not shaken	71	1	1	1	0
	Shaken	74	2	3	1	0
	Selfed, hand pollinated	69	0	0	0	0
	Crossed, hand pollinated	68	32	47	32	93
	Open pollinated	61	58	95	58	91
5	Not shaken	98	0	0	0	0
	Shaken	89	0	0	0	0
	Selfed, hand pollinated	59	4	6	3	66
	Crossed, hand pollinated	57	29	50	29	79
	Open pollinated	129	87	67	56	91
8	Not shaken	51	0	0	0	0
	Shaken	45	0	0	0	0
	Selfed, hand pollinated	46	0	0	0	0
	Crossed, hand pollinated	57	0	0	0	0
	Open pollinated	71	68	95	54	81
11	Not shaken	66	0	0	0	0
	Shaken	78	0	0	0	0
	Selfed, hand pollinated	77	3	4	3	33
	Crossed, hand pollinated	69	62	89	53	73
	Open pollinated	211	196	93	52	100
12	Not shaken	53	0	0	0	0
	Shaken	78	12	15	12	50
	Selfed, hand pollinated	52	0	0	0	0
	Crossed, hand pollinated	65	44	67	44	97
	Open pollinated	114	102	89	99	90
3	Not shaken	54	0	0	0	0
	Shaken	117	0	0	0	0
	Selfed, hand pollinated	70	9	13	6	33
	Crossed, hand pollinated	66	49	74	48	93
6	Not shaken	92	0	0	0	0
	Shaken	62	1	1	1	0
	Selfed, hand pollinated	56	3	5	2	100
	Crossed, hand pollinated	52	42	80	42	90
7	Not shaken	41	0	0	0	0
	Shaken	53	0	0	0	0
9	Not shaken	37	0	0	0	0
	Shaken	60	0	0	0	0
10	Not shaken	53	0	0	0	0
	Shaken	55	4	7	4	0

With the abundance of pollen present and the uniform distribution of it obtained by shaking, it is unlikely that pollination did not take place in a majority of the flowers. The low percentage of carpels that were stimulated by careful hand pollination with pollen collected in the bag further supports the writer's belief that defective

pollen or incompatability and not failure to effect pollination is the cause for the poor set of seed under the first three treatments.

The data on plants 4 and 8 might indicate that these plants were completely self sterile since they produced no viable embryos by any of the selfing methods.

In 8 out of 9 cases the use of a mixture of pollen from other plants applied by hand resulted in a larger percentage of stimulated carpels than hand pollination with pollen collected within the bag. In the ninth case, no set was obtained from either treatment. This also points to self sterility as the operative factor in producing a low percentage of seed.

On a few plants the percentage of stimulated carpels set under the bags where cross pollinations were made was almost as large as on the open pollinated and unbagged racemes, suggesting that in these cases the presence of the bag exerted no deleterious effects on fertilization and subsequent development of the embryo.

Garden Experiments

Roots for the 1927 experiment were grown from seed, presumably selfed, that had been grown under cloth cages from roots of the varieties listed in Table II. Roots for the 1928 experiment were selections from commercial varieties, and from line bred strains of varying degrees of uniformity.

They were planted the latter part of May in fertile garden soil 3 by 4 feet apart. A stake was placed by each plant to which the flower stem was later tied.

Heavier bags than those used in the greenhouse test were found to be necessary to withstand outdoor conditions. The same size and grade that is used for apple pollination studies gave very satisfactory service. To prevent breakage of the flower stems it was necessary to support the bags. This was satisfactorily accomplished by tying a soft cotton string about the base of the bag (and cotton), passing it thru a paper clip in the outer end of the bag and tying the string to the stake in such manner that the bag was held nearly horizontal and free to move sidewise with air currents.

The stems at the base of each bag were tapped with a light bamboo rod about noon of each day during the blooming period. This dislodged the pollen from the anthers and effectively distributed it thruout the bag. Cotton wrapped about the stems was again used to exclude insects from the bags. Several racemes or small branches of the main inflorescence were placed in each of these bags, the tip of each raceme being nipped off.

As soon as the seeds were brown the stems were cut and the bag with its contents stored until the counts could be made. Only those bags that were intact at harvest time are included in the records. Many were torn or broken open and were discarded.

Twenty-nine plants were used in the 1927 test and altho an average of 5 bags per plant were started, the final number was about 2.5 bags per plant. The distribution of bags on the different plants is shown in Table II. The approximate number of flower clusters per bag ranged from 38 to 556 with an average of 155 per bag.

TABLE II—PRODUCTION AND GERMINATION OF TABLE BEET SEED UNDER GLASSINE BAGS. GARDEN-GROWN 1927

Variety	Seedsman	Plant No.	No. Bags	No. Bags No Seed	Number of Flower Clusters: Total	Set	Per cent Set	Planted	Per cent Germinated
Edmands Blood Turnip	Rice	24-1	1	0	239	1	.42	1	100
		24-2	1	0	556	29	5.22	29	37
		24-3	2	0	600	7	1.16	7	0
		24-4	1	0	211	5	2.37	5	80
		24-5	15	0	2632	232	8.81	228	68
Detroit Dark Red	Ferry	26-1	5	2	902	41	4.54	41	36
		26-3	2	2	260	0	0.0	0	0
		28-2	3	3	396	0	0.0	0	0
		30-1	3	2	519	2	0.39	2	0
		30-2	3	1	339	5	1.46	5	40
		30-3	3	0	654	55	8.41	53	50
Early Wonder	Woodruff	36-1	3	3	446	0	0.0	0	0
		36-2	4	3	693	2	0.28	2	0
		36-4	1	1	200	0	0.0	0	0
		36-5	2	2	150	0	0.0	0	0
Detroit Dark Red	Rice	46-1	2	1	268	2	0.74	2	0
		49-5	1	1	149	0	0.0	0	0
		50-1	3	2	554	4	0.72	4	25
		50-2	2	2	372	0	0.0	0	0
		50-3	2	2	88	0	0.0	0	0
Early Blood	Woodruff	54-1	2	2	166	0	0.0	0	0
		54-2	2	0	207	57	27.5	56	67
		54-3	2	2	173	0	0.0	0	0
Crimson Globe	Woodruff	59-1	2	2	200	0	0.0	0	0
		59-2	1	1	150	0	0.0	0	0
		59-3	2	2	150	0	0.0	0	0
		59-4	1	1	65	0	0.0	0	0
		59-5	2	2	149	0	0.0	0	0
		59-6	2	2	200	0	0.0	0	0
Total or Average		29	75	41	11,688	442	3.78	435	58

The average number of flower clusters per bag in which one or more carpels were stimulated was 5.8 with a range of 1 to 51. In terms of percentage stimulated these numbers represent 0.25 and 39 per cent respectively. Per plant, however, the highest per cent stimulated was 27.5 with all the rest under 9 per cent. Only 52 per cent of the bags contained any stimulated clusters and these were distributed on 48 per cent of the plants.

Germination tests, however, showed only 9 or 31 per cent of the plants produced viable seed. One or more plants from each of the original varieties produced no progeny indicating that self sterility is probably common to all varieties. The results from Early Wonder and Crimson Globe would indicate that these particular strains are highly if not completely self sterile.

Since the 1928 results are essentially the same as those for 1927 and in order to conserve space, the table has been omitted and only the summary will be given.

Sixty plants were used in this test on which an average of 4.4 bags per plant were intact at harvest. Fifty-five of them had 3 or more bags per plant with 6 the highest number. In number of flower clusters per bag, they ranged from 25 to 581 with an average of 234. Per plant, the number of flower clusters bagged ranged from 170 to 2292 with an average of 1050.

The total number of stimulated flower clusters was 1797, or 2.85 per cent of the total flower clusters enclosed. The range per bag in numbers was 1 to 158; in per cent from .21 to 55 respectively. The average number per bag, all bags considered, was 6.68; considering only those containing stimulated clusters the average was 13.1.

Forty-eight per cent of the bags contained no stimulated clusters while only 15 per cent of the plants failed to produce any stimulated clusters.

Germination counts showed that only 21.7 per cent of the stimulated clusters that were planted, produced seedlings. Thirty-three per cent of the plants that produced one or more stimulated carpels failed to produce any seedlings, and added to the 15 per cent that produced no stimulated clusters made a total of 48 per cent that were not able to perpetuate themselves under these conditions. An additional 15 per cent produced only 1 cluster with viable embryos, another 11 per cent produced only 2, and another 5 per cent only 3 clusters with viable embryos.

Discussion

The above results agree in general with those reported for sugar beets. Shaw (1) unfortunately does not list the results of his close pollination experiments by individual plants, but groups them all together under treatments.

The percentage of stimulated carpels by hand selfing in the 1927 greenhouse experiment which is comparable with his two methods of "close pollination" was 16 per cent for the average of all plants. His figures were 4.13 by one method (modified technique) and 7.89 per cent by the other. Altho no mention is made of the presence of plants which were self sterile by this method of pollination, one is

led to believe that self sterility was present for in writing of the set of seed on mother beets isolated 2 miles from each other Shaw states that "several of the plants remained entirely sterile, although otherwise their growth was normal."

Stewart and Tingey (2) report 78 per cent of their sugar beets as producing one or more seeds. No mention is made of whether these seeds were germinated. Thirteen out of 58 produced less than 10 seeds each and germination would probably have disclosed some of these plants as producers of non-viable embryos. No attempt was made to make the bags insect-proof by placing cotton about the stems and according to Reed (3) bagging without excluding insects increases greatly the set of seed even tho the plants are isolated. Reed also reports that 24 sugar beets from which insects were excluded by bagging the entire plant with large flour bags produced no seed.

Artschwager (4) states he has been able to secure seed of sugar beets under bags and mentions the work of Nellson and of Dudok van Heel who also obtained varying degrees of self-fertility under bags. They also found some self sterile races of sugar beets.

Mr. H. R. Murray of the Connecticut Experiment Station, New Haven, Conn., in correspondence stated that he was unable to secure any seed from between 300 and 400 "parchment bags" placed on beets growing at the stock seed farm of the Associated Seed Growers at Milford, Conn. Cotton was wrapped tightly about the stems to exclude insects and altho shaking was not practiced the prevalence of wind in this location was thought to provide considerable agitation.

These facts would seem to point to the greater use of inbreeding as a method of improving both table and sugar beets, and indicate the need of further studies on technique and the isolation of self fertile strains.

Conclusion

The results of one year's work in the greenhouse and two in the field in attempts to produce selfed table beet seed under glassine bags indicate, (1) there is considerable self sterility and varying degrees of self fertility in the table beet. (2) There is a possibility of isolating strains that are sufficiently self-fertile to perpetuate themselves. (3) Only a small percentage of the stimulated carpels contained viable embryos. (4) Under greenhouse conditions, the set of seed was increased by shaking the bags at noon or by hand pollination with the pollen collected within the bag. (5) Under field conditions, it might prove practical to hand pollinate a portion of the flowers under the bags. (6) The bags per se had very little, if any, deleterious effect on fertilization and subsequent development of the embryo.

Literature Cited

1. Shaw, H. B. Self, close and cross fertilization of beets. N. Y. Bot. Garden Memoirs VI. 3:149. 1916.
2. Stewart, George and Tingey, D. C. A method for controlling pollination of sugar beets. Jour. Amer. Soc. Agron., 19:126. 1927.
3. Reed, Ernest. Sterility and inbreeding in beets. Hort. Soc. of N. Y. Memoir 3:59. 1927.
4. Artschwager, Ernest. Micro- and macrosporogenesis in sugar beet with special reference to the problem of incompatability. Hort. Soc. of N. Y. Memoir 3:295. 1927.

Asparagus Land Rejuvenation
(*Preliminary Report*)

By G. C. Hanna, *Asparagus Field Station, Rio Vista, California*

ABOUT 65,000 acres of the Sacramento-San Joaquin Delta section of California are devoted to asparagus culture. Between 80 and 90 per cent of the crop produced in this region is canned white. Land adapted to the production of white asparagus for canning is rather limited. This land must be of the proper mixture of muck and sediment to afford a loose and productive soil which can be subirrigated and kept free of clods and crust. This type of soil will also allow the asparagus spear to grow straight, a very important consideration from the standpoint of the canner because only straight spears fit well into the can.

Experience has shown that the raw peat soils of the Delta, which contain very little sediment, produce light yields; and the crop has therefore not been a very profitable one. On the sediment soils, on the other hand, the yields are usually good; but they are difficult to keep well-pulverized and free from clods. As the spears grow through the sediment soils many of them become crooked, and there is usually, in consequence, a high percentage of waste. Furthermore, most sediment soils do not subirrigate readily.

As stated above, the area of the best soil is rather limited. At the present rate of increase in planting, the entire area will soon be growing asparagus, or will have been planted to asparagus at one time or another.

The experience of most asparagus growers indicates that land cannot be successfully replanted to this crop even if several years elapse between the removal of the old crop and the planting of the new one. No recorded studies have been made to determine the cause of the deleterious effect. Neither have systematic experiments ever been outlined to determine how soon old asparagus fields can be replanted to asparagus when given different fertilizer treatments or when subjected to different systems of crop rotation. Loisel (1) claims that in France the land should not be replanted to asparagus for 25 or 30 years.

Within the next few years thousands of acres of old asparagus beds in the Delta region of California will be plowed out. If the acreage is to be maintained it will be necessary to replant on old asparagus land or to plant the new beds on what is now considered border land and not so well adapted to the growing of the crop. The Canners' League of California, anticipating a threatened shortage of the more desirable land for the production of asparagus, has helped to initiate experiments looking toward the solution of this problem. A 60-acre field of asparagus on Ryer Island, planted in 1918, was selected as the location for this work. The tract was leased by the Canners' League for a period of 12 years. Immediately after the 1929 cutting season, one-third of the field (20 acres) was divided into 33 plots, to receive 11 different treatments, each treatment to be run in triplicate. The old crowns from two plots were

plowed out and hauled from the field. Preliminary determinations showed that somewhat less than one-half of the total weight of the roots and rhizomes can be removed by this method. The crowns in the remaining plots were chopped up to a depth of about 11 inches by means of a rotary plow which cut the roots into lengths of from one to two inches. The plan for the first 20 acres is given in Table I. The first application of fertilizer will be put in the first furrow and mixed with the soil before the crowns are planted. After the first year the fertilizer will be applied in summer immediately after the harvest season has ended.

TABLE I—PLAN OF EXPERIMENT

Plot Number	Disposition of Old Crowns	Date When Plot is to be Replanted to Asparagus	Treatment of Plots
1	Chopped	January 1930	No treatment.
2	Removed	January 1930	No treatment.
3	Chopped	January 1930	300 lbs. calcium nitrate, 400 lbs. potassium sulfate, 800 lbs. treble superphosphate per acre.
4	Removed	January 1930	Same as plot 3, but sodium nitrate used instead of calcium nitrate.
5	Chopped	January 1930	Same fertilizer application as plot 4.
6	Chopped	January 1930	300 lbs. calcium nitrate per acre.
7	Chopped	January 1930	400 lbs. potassium sulfate per acre.
8	Chopped	January 1930	800 lbs. treble superposphate per acre.
9	Chopped	January 1932	First year barley; second year summer legume.
10	Chopped	January 1934	First year summer legume; second year barley; third year summer legume; fourth year barley.
11	Chopped	January 1934	First three years alfalfa; fourth year barley.

The remaining 40 acres of the old asparagus bed has been divided into 66 plots, from which yield records will be kept to test the native productivity of this soil and to serve as a check for the plantings that are to follow. Twenty acres of the old bed will be plowed out after the cutting season of 1931. It is hoped by that time that some information will have been obtained on the first planting that will help to determine the methods to be used. Most of the second block will probably be replanted in January 1932. The last 20-acre section will be cut until the summer of 1933; then it will be plowed out. By that time the results of four years' work on the first 20-acre field will be available, as well as two years' results on the second 20-acre field. The results obtained from the fields planted four and two years previously will help to determine the method of handling the plots that are to be planted in January 1934.

Dividing the land into three parts, laying out permanent plots, and planting at two-year intervals make it possible to get performance records of the various plots (except of the first planting) and to test out the productivity of the soil before different treatments are applied.

LITERATURE CITED

1. LOISEL, M. L'Asperge, culture naturelle et artificielle. Librairie Agricole de la Maison Rustique. (10th ed.) 136. F. Lesourd, Paris. 1924.

The Improvement of Prunus Tomentosa

By G. L. Slate, *Experiment Station, Geneva, N. Y.*

VARIOUS writers, among them Jack (3), Hedrick (2), and Darrow (1), have called attention to the merits of *P. tomentosa* as an ornamental and fruit-producing plant. Considerable variation has been noticed by these writers and by Koehne (4), who describes ten botanical varieties, most of them based on flower characters, usually the size of the petals. In spite of the fact that the merits of *P. tomentosa* have been known for nearly 40 years, little has been done to improve it, and most of the plants disseminated have been seedlings. In the plant inventories of the Office of Foreign Seed and Plant Introduction, *P. tomentosa* has been listed under 42 numbers.

As grown at Geneva the immediate value of this cherry seems to be as an ornamental and as a fruit for the backyard. The small size of the plant which rarely exceeds eight feet in height, and its attractive appearance in flower, foliage, and fruit, make it valuable for this purpose. After observing the variation among a number of seedlings, the writer is inclined to believe that it will not be difficult to develop a variety of commercial value. It is the purpose of this paper to discuss the results obtained by raising a number of seedlings of *P. tomentosa.*

In the summer of 1925 open-pollinated seed was saved from four trees growing on the Station grounds, and designated in this paper as Geneva Nos. 1, 2, 3, and 4. Through the kindness of Mr. E. F. Palmer of the Horticultural Experiment Station, Vineland, Ontario, seed was also obtained from three trees, Vineland Nos. 1, 2, and 3. The trees at Geneva were obtained from the United States Department of Agriculture as seedlings under F. S. P. I. No. 20075, and the Vineland trees were descendants of a tree secured from the same source. Approximately 1200 seedlings were set five feet apart each way in the fall of 1926, and in 1929 practically all of them fruited.

Several seedlings superior to the parent trees were found, and two or three were outstanding. In making selections the chief points considered were lateness of bloom, size and firmness of fruit, and productiveness of the plant. The seedlings were described and classified as follows.

Season of Bloom and of Fruit

Owing to warm weather during the latter part of March, 1929, the blooming season started rather early. A cold period about the middle of the month prolonged the season considerably so that there was a range of 25 days between the first to bloom on April 3rd and the last on April 28th. The Vineland seedlings had nearly all bloomed by April 13th, but the Geneva seedlings were about 10 days later. It is evident, then, that there is sufficient variation in season of bloom to make it worth while to continue selection for this character.

The season of ripening was much shorter than the blooming season, the range being 13 days. The first seedling ripened July 6,

the last July 19. Owing to the fact that the fruit keeps well on the plant, the need of selection in this direction is not great.

Flower Bud Color

The seedlings were grouped into three classes according to the color of the flower buds, the classes being white, tinged pink, and pink. The flowers when open were nearly white or only faintly tinged pink. Two varieties, Vineland No. 2 and No. 3 gave 8 and 18 per cent, respectively of pink-budded seedlings, whereas none of this class were found among the progeny of Geneva No. 3 and No. 4 and Vineland No. 1. This character is important from the ornamental standpoint as the pink-budded types were unusually attractive.

Yields

If this fruit is to be of commercial importance, the plants must be productive, and the yields for 1929 indicate that only a small number of seedlings could be classified as bearing a full crop. Of the total population of nearly 1200 plants, only 72 had full crops. About half the seedlings of Geneva No. 1, No. 2, and No. 3, produced medium crops, while the seedlings of Geneva No. 4 and Vineland No. 1, No. 2, and No. 3 were nearly all unproductive. From the standpoint of securing productive sorts, the first three parents were decidedly superior to the others.

It is possible that there may be a correlation between the early blooming and the light crops of the Vineland seedlings, but it should be noted that the seedlings of Geneva No. 4 which all bloomed late were nearly all unproductive. During the blossoming season the lowest temperature experienced was 31 degrees F and no pistil injury was noted at any time.

Fruit Characters

The seedlings were sorted into three groups on the basis of size of fruit. The large class consisted of those seedlings ranging in size from 6/16 to 8/16 of an inch in diameter, the medium class ranged from 5/16 to 6/16 of an inch and those in the small class were from 4/16 to 5/16 of an inch. The exact point of division was somewhat arbitrary as the larger fruits of one class approached in size the smaller fruits of the next larger class. A few that were unusually large or small were included in the large and small classes. The proportion of seedlings in the class for large fruit varied considerably with the different parents. The populations raised from Geneva No. 1, No. 2, No. 3, and No. 4 had respectively 9, 23, 28, and 19 per cent of large-fruited seedlings. Vineland No. 1, No. 2, and No. 3 yielded 53, 37, and 29 per cent of large-fruited seedlings. The populations yielding the largest fruited forms were not necessarily those which had the highest proportion of large seedlings. The largest-fruited types were obtained from Geneva No. 2 and No. 3, several plants bearing fruit exceeding one-half inch in diameter. It is worthy of note that the large-fruited seedlings usually had good crops, except in the case of the Vineland progeny.

A correlation between size and color of fruit was noted, the class for large size having a high proportion of light-colored seedlings, this proportion decreasing in the medium and small classes, and the proportion of dark-colored seedlings increasing in the latter classes. This correlation is most striking among the progeny of Geneva No. 3 and No. 4. Among the seedlings of Vineland No. 3 were 11 with white fruit. White-fruited forms are apparently rare, as systematic works do not mention them. White forms have been listed under four numbers in the Plant Inventories of the U. S. Department of Agriculture.

The seedlings were not classified as to texture of flesh, but it was noted that the progeny of Vineland No. 1 were firmer than the average. Several unusually firm seedlings were found in this lot, one being as firm as a Bigarreau cherry. These firm types are, of course, very valuable for breeding as the majority of the seedlings are too soft for commercial purposes.

Foliage and Tree Types

In addition to the normal type of tree and foliage several others appeared. These types were very distinct and although some variation was evident within a class, it was possible to classify the plants at a glance. These types may be described as follows:

Small foliage type: The leaves vary somewhat in size among the different seedlings in this class, but all are much smaller than the foliage of the normal type. The margins are wavy or crinkled. The tree is very dense in habit, upright, spreading, and always unproductive. Most of this class had small flowers. This type is decidedly inferior to the normal type for fruit or ornamental purposes and should not be propagated. As nearly a fifth of the progeny of three parents were of this type, it should be eliminated from seedling stocks by nurserymen or a superior type budded on these trees. This type was not found among the progeny of the Vineland parents. Small size of petals was usually correlated with this type of foliage, the proportion of small flowers in this class ranging from 80 to 90 per cent. A few plants with small petals were present among the normal foliage type, but the number did not exceed 4½ per cent in any case.

Yellow foliage type: The foliage of this class was of a yellowish cast and the leaves slightly smaller than the normal type. The bushes were upright, usually being nearly vase-shaped. The majority of this type was found among the progeny of Geneva No. 4, 63 per cent of the population being in this class.

Spreading type: The tree is low and very spreading, the branches are willowy and drooping, the lower branches often touching the ground. The foliage had a yellowish green cast. Three plants of this type appeared among the Vineland seedlings.

Open type: The tree is small, of open habit and scant foliage. About one-fourth the progeny of Vineland No. 1 were in this class, but none were present in the other populations.

It is evident from a study of this data that considerable variation may be found in a population of *P. tomentosa* seedlings, and that the aracters exist which if combined in one individual will make a worthwhile addition to our list of cultivated fruits. Now that definite pes have been selected these combinations may be made.

The number of seedlings of merit in a population gives some indication of the breeding value of a variety. Of the entire population of 1182 seedlings only 54 or 4.5 per cent were of real merit. Two of these were exceptionally good. From the standpoint of producing good varieties Geneva No. 2 and No. 3 are the best parents. Vineland No. 1 and No. 3 gave the most interesting and unusual seedlings.

LITERATURE CITED

1. DARROW, G. M. The Chinese bush cherry. Jour. Heredity, 15:169. 1924.
2. HEDRICK, U. P., *et al.* Cherries of New York. 1915.
3. JACK, J. G. Prunus tomentosa. Gard. and For., 5:580. 1892.
4. KOEHNE, E. In Sargent, Plantae Wilsonianae, 1:268. 1913.

Chromosome Counts in *Vitis* and Related Genera

By Karl Sax, *Harvard University, Cambridge, Mass.*

THE genus *Vitis* is divided in two subgenera, Euvitis and Muscadinia. The first subgenus contains numerous species while the second is represented by a single species, *rotundifolia* (5). Rehder describes 24 species of *Vitis*, but states that about 60 species are found in the northern hemisphere. *Vitis vinifera* is the only grape commonly grown in Europe and is probably of Caucasian origin. The species *cordifolia, rubra, vulpina, monticola, rupestris, Baileyana, cinerea, arizonica, californica, Lecontiana, aestivalis, candicans, labrusca* and *rotundifolia* are natives of North America. The species *amurensis, flexuosa, reticulata, Kaempferi, pentagona, Thunbergii, Romaneti, Davidi* and *Piasezkii* are of oriental origin. (5)

The horticultural varieties of economic importance have originated from *vinifera, labrusca rotundifolia, aestivalis* and *vulpina* (*riparia*) and from crosses between certain of these species (3). Hybrids between *vinifera* and *labrusca* have produced many of our best varieties. Wellington writes that the varieties often described as seedlings of *labrusca*, such as Concord and Worden, are probably hybrids between *labrusca* and *vinifera*. Numerous hybrids have been made between species of the Euvitis group and especially between *vinifera* and many of the American species. The Oriental species have not been used in producing commercial varieties, but according to Rehder, *V. Andersonii* is a cross between the American *vulpina* and the Japanese species *Kaempferi*. So far as data are available, it appears that the species of the Euvitis group are interfertile and produce fertile hybrids (plants with functional gametes). Detjen (1) has found that *V. rotundifolia* is difficult to cross with many of the Euvitis species and doubts if crosses can be made in some cases. The hybrids obtained are intermediate in character and are almost completely sterile due to aborted gametes (2).

Chromosome counts of Vitis species have been made to determine the cytological relationship between the two subgenera and to see whether sex is associated with chromosome number. The closely related genera *Ampelopsis* and *Parthenocissus* have also been studied. Chromosome counts were obtained from root tips of cuttings from plants in the Arnold Arboretum and from pollen mother cells. Cuttings of commercial varieties were obtained from Mr. Wellington at Geneva and cuttings of *V. rotundifolia* were provided by Mr. Williams of N. C. State College.

The somatic chromosome number (counted from root tips or determined from p.m.c. counts) is 38 for the following species, hybrids, and varieties, *V vulpina* and the related species *Trealeasi* and *Longii, rupestris*,* *amurensis, cinerea, Kaempferi, labrusca*,* *Andersonii* (*vulpina* x *Kaempferi*), *Slavinii* (*vulpina* x *Lecontiana*), *Champinii* (*candicans* x *rupestris* or *Berlanderi*), Clinton* (*riparia labrusca*), Charboro (*vinifera*), Muscat Hamburg* (*vinifera*), Chas. Ciotat (*vinifera*), Cinsaut (*vinifera*), Belle of Pipe (*labrusca*), Delaware (*labrusca Bourquiniana Vinifera*) and Niagara* (*labrusca*

vinifera). All of the species of the Euvitis group which have been examined have 38 somatic chromosomes with one possible exception. A *vinifera* plant from China apparently has 40 somatic chromosomes but the counts were based on only a few figures and can not be accepted as conclusive. The species and varieties marked with an asterisk indicate that counts have previously been obtained by Nebel (4).

Counts were obtained from a male plant of *V. rotundifolia*, the only species in the Muscadinia subgenus. Numerous figures show that this species has 40 somatic chromosomes. There are also 40 somatic chromosomes in the closely related genera *Ampelopsis* and *Parthenocissus*. Counts were obtained for *A. brevipedunculata*, *humulifolia*, and *cordata*, and for *P. tricuspidata*, *vitacea*, and *quinquefolia*. It is interesting to note that *V. rotundifolia* is more closely related taxonomically to these two genera than any of the other species of Vitis (5). In view of the taxonomic and cytological relation one would suspect that crosses might be made between *V. rotundifolia* and species of *Parthenocissus* or *Ampelopsis*, but such crosses have been tried by Detjen (1) without success.

In several species both male and female plants were examined but no differences in chromosome number could be found. The chromosomes are very small and if size differences exist they would be difficult to detect. Trabants were frequently observed, but could not be found in all preparations, probably due to differences in fixation.

The fact that species of the Euvitis group have 38 somatic chromosomes while *V. rotundifolia* has 40 chromosomes can hardly account for the amount of sterility found in hybrids between these two subgenera. If sterility is due only to unbalanced numerical relations, there should be no sterility of gametes in F_1 since the gametes should have either 19 or 20 chromosomes, the same number as found in the parental species. In view of the difficulty of making such crosses and the high degree of sterility found in F_1 hybrids it appears that rather fundamental differences exist between the chromosome complexes of the two subgenera of *Vitis*. A cytological study of these F_1 hybrids should be of considerable interest.

Literature Cited

1. Detjen, L. R. The limits in hybridization of *Vitis rotundifolia* with related species and genera. N. C. Agr. Exp. Sta. Tech. Bull. 17. 1929.
2. ————. Some F hybrids of *Vitis rotundifolia* with related species and genera. N. C. Agr. Exp. Sta. Tech. Bull. 18. 1919.
3. Hedrick, U. P. The grapes of New York. 1908.
4. Nebel, B. Zur cytologie von *Malus* und *Vitis*. Die Gartenbauwissenschaft. 1. Bd. 6. Heft. 449. 1929.
5. Rehder, A. Manual of cultivated trees and shrubs. New York. 1927.

TABLE I—SUMMARY OF RESULTS OF POLLINATING CABBAGE FLOWERS IN THE BUD AND AT ANTHESIS.

Pedigree No.	Anthesis Pollinated						Bud Pollinated					
	No. of Plants	Total					No. of Plants	Total				
		Fl. Poll'd	Fl. With Seeds	Seeds	Per cent Set	Av. No. Seeds per Pod		Fl. Poll'd	Fl. With Seeds	Seeds	Per cent Set	Av. No. Seeds per Pod
1-1-16-3-D*	1	18	3	6	17	2	1	44	16	46	36	2.9
1-4-41-2-B*	1	11	0	0	0	0	1	31	1	1	3	1
1-6-87-2-E*	1	53	0	0	0	0	1	48	0	0	0	0
1-1-16-3	1	22	9	13	41	1.5	2	77	62	454	80.5	7.3
1-1-16-6	4	91	22	36	24	1.6	4	150	140	1922	93.3	13.7
1-4-41-1	4	113	6	8	5	1.3	4	207	143	2104	69.1	14.7
1-4-41-2	3	71	1	1	1.4	1	3	134	107	1194	79.8	11.2
1-6-52-1	5	129	1	1	.8	1	5	245	192	2334	78.4	12.2
1-6-81-1	4	94	7	8	7	1.1	4	154	136	1540	88.3	11.3
1-6-87-1	4	91	4	6	4	1.5	4	182	135	1473	74.2	10.9
1-6-87-2	4	140	2	2	1	1	4	202	151	1701	74.7	11.3
Total	29	751	52	75			30	1351	1066	12722		
Omitting families 1-1-16-3 & 1-1-16-6		638	21	26				1124	864	10346		
Averages					6.92	1.44					78.9	11.93
Omitting Families 1-1-16-3 & 1-1-16-6					3.28	1.24					76.9	11.97

*See text for discussion of these exceptional plants. They have been omitted in making up the averages for the families and for the main table.

inserting the points of sterile forceps between the upper ends of the sepals; when released, the forceps spread the sepals and exposed the stigma, which was brushed with fresh pollen from a protected flower on the same plant. On several plants a bag was tied over the raceme, and left undisturbed for 10 days. In a few cases seed was secured, but the set was less than in those hand pollinated at anthesis. Seed was secured from such spontaneous pollinations only in the case of the line 1–4–41–1, plants B and D. In this line the stigma forces apart the sepals and protrudes two or three days before the flower opens. Pollen falling on this young stigma would probably be as effective as pollen applied in the bud. In July the seeds were harvested, and those of each pod counted.

Table I gives the summary of the tests made on these plants. Flowers hand-pollinated at anthesis gave a set of 6.92 per cent. If the two related families 1–1–16–3 and 1–1–16–6 are omitted it is reduced to 3.28 per cent. These two families are apparently approaching semi-self-compatibility. When pollen was applied from one to five days before anthesis (bud pollinated) an average set of 78.9 per cent was obtained. Three plants, 1–1–16–3–D, 1–4–41–2–B, and 1–6–87–2–E, behaved differently. The plant 1–4–41–2–B was noted as "badly wilted" at the time of testing, so that the difference in physiological conditions probably explains the difference in behavior from its three sisters. No note was made in reference to the others, so that internal conditions must explain their behavior. Both set seed normally when open pollinated. We may be dealing here with a case of true sterility, and not of simple incompatibility. The pollen appeared normal in both cases. These three plants have been omitted in calculating averages for the entire table.

The average number of seed per pod in the plants pollinated at anthesis is 1.47. Flowers pollinated in the bud produced 11.8 seeds per pod. As indicated in the table the range between families is considerable, due most likely to the difference in hereditary constitution.

Table II shows the data from a representative plant. It is obvious that self-pollinations made in the bud give a much higher set. In almost every case the first few flowers that were bud pollinated, the lowest and oldest on the raceme, as for example flowers number 1–5 on plant 1–6–87–2–D, failed to set. Flowers pollinated as younger buds gave much better results. The older flowers pollinated in the bud opened, but the ovules died before the sperm nuclei could reach them. These apparently were the flowers that opened the day after pollen had been applied. But the flowers that opened two days after pollination set seed in abundance. The time between pollination and degeneration of the egg cell was apparently long enough to allow the sperm nucleus to reach the egg; and for the next two or three days the union of egg and sperm occurred freely, as evidenced by the set of seed. The flowers unprotected from insects set seed normally, although pollen could not have been applied to the stigma before anthesis. Either the insects had a better technique in pollination, or the quality of the pollen was different. Hand pollinations

at time of anthesis have yielded a good set of seed in crosses between different lines. Since there were three unrelated lines of cabbage present, as well as the commercial varieties in bloom in various parts of Colma, a wide variety of pollen was available. The pollen tubes from this pollen could probably grow rapidly enough to reach and fertilize the egg before degeneration set in, even if applied at or after anthesis.

TABLE II—EFFICIENCY OF POLLINATIONS MADE BEFORE AND AFTER ANTHESIS. DATA TAKEN FROM A REPRESENTATIVE PLANT.

Pedigree No.	Raceme Pollinated at Anthesis				Raceme Pollinated Before Anthesis			
	Date Poll'd	No. Fl. Poll'd	Fl. No.	No. Seeds per Pod	Date Poll'd	No. Fl. Poll'd	Fl. No.	No. Seeds per Pod
1-6-87-2-D			1	0			1	0
	4/28	3	2	0			2	0
			3	0			3	1
							4	0
			4	0			5	1
			5	0			6	23
	4/29	5	6	0			7	1
			7	0	4/28	15	8	21
			8	0			9	2
							10	23**
			9	0			11	20
	4/30	3	10	0			12	16
			11	0			13	19
							14	23
			12	0			15	21
	5/1	4	13	0				
			14	0			16	1
			15	0			17	20
							18	11
			16	0			19	16
			17	0			20	5
	5/2	4	18	0	5/1	11	21	21
			19	0			22	21
							23	17
							24	13
							25	0
							26	18

**Flowers above open on 5/1.

From a practical seed growers standpoint the data presented in this paper are of interest. It explains in one way the small amount of seed obtained from cabbage or cauliflower plants under conditions of isolation. Since self-incompatibility is inherited, as appears from Detjen's work, inbreeding and selection may cause the development of lines of plants which would be incompatible when pollinated inter se. Preliminary tests made on these same cabbage plants indicate that such a situation may be present here. A similar situation has been described in Nicotiana by East and Mangelsdorf (1926).

Literature Cited

1. Detjen, L. R. Sterility in the common cabbage (Brassica oleracea L.) Mem. Hort. Soc. New York 3:277. 1927.
2. East, E. M., and Mangelsdorf, A. J. Studies on self-sterility VII. Heredity and selective pollen tube growth. Genetics 11:466. 1926.
3. Jones, D. F. Selective fertilization and the rate of pollen tube growth. Biological Bul. 43:167. 1922.
4. Kearney, T. H., and Harrison, G. J. Selective fertilization in cotton. Jour. of Agri. Res. 27:329. 1924.
5. Roemer, T. Uber die Befruchtungverhaltnisse verschiedner Formen des Gartenkohls (Brassica oleracea L.) Zeit fur Pflanzenzuchtung 4:125. 1916.
6. Walker, J. C., Monteith, J., Jr., and Wellman, F. L. Development of three midseason varieties of cabbage resistant yellows (Fusarium conglutinans Woll.) Jour. Agri. Res. 35:785. 1927.

The Use of Bees in Apple Sterility Studies

By A. E. Murneek, *University of Missouri, Columbia, Mo.*

PENDING the discovery of "the ideal procedure," an acceptable orchard method of apple sterility studies ought to contain at least the following desirable features: It should (a) leave all the blossoms of a tree intact; (b) assure the transfer of pollen from a desirable variety in the most natural way (as it is done by insects) and at the most appropriate time; (c) interfere as little as possible with the normal physiological functions of the tree; and (d) permit to express the results in a manner comparable to a commercial set or yield of fruits. Obviously in this respect some methods are more desirable than others.

Despite the many difficulties that were anticipated and that perforce had to be overcome, the writer has resorted lately to the use of large screened cages and package bees in orchard studies of the pollination requirements of apples. This decision was a logical outcome of his previous rather extensive experience with various paper bag methods. The demerits of the latter need not be stressed here. They have been amply discussed and emphasized by other investigators, especially by MacDaniels (4) and Howlett (3). The present paper is a preliminary report of the first year's experience and of results with the screened cages.

Standard commercial varieties of apple trees, 18 years old, bearing, and in a vigorous and healthy state were used as material. They are growing in sod and have been receiving 4 pounds of sulphate of ammonia approximately 2 weeks before flowering. Early in the spring, when an examination of buds indicated which trees were going to flower abundantly, cages were constructed so as to enclose one-half of each selected specimen. These cages were made of strong lumber and covered with ordinary screen wire. They were mostly 20 feet by 12 feet by 16 or 18 feet high and had a partition in the center. Thus two quarters of each tree were screened separately and the remaining half left uncovered. Care was exercised to make the cages insect tight. The initial cost per average two-compartment cage was $133.20 of which three-fourths went for material and the rest for labor. Current expenses, consisting primarily of the cost of bees and their care, tagging of branches, and taking of records were around $5.50 per cage.

While the flowers were coming into full bloom, bouquets of large branches of the desirable pollen variety were placed in selected compartments and package bees were ordered from the South. As soon as most of the flowers were open, a pound of bees was transferred to a specially construted small hive and put into each compartment. Everything went well excepting with the weather. It was worse than confounded: cold and rainy during the period of pollination with two destructive hailstorms thereafter. Still there were occasional clear, though cold, days when bees visited the flowers in large numbers. The results perforce are subject to this most influential and most disturbing factor—bad pollination weather.

As soon as the petals had dropped, hives and bouquets were removed and cloth spread on the ground in each cage, to facilitate the gathering of the various drops. At the same time the tops and a number of side sections were removed from each cage to allow the entrance of a maximum amount of light.

Though the weather was very bad indeed for this kind of investigation, the results indicate rather clearly that package bees may be used effectively in apple sterility studies. The principal advantages of this method over others are that it permits the pollination of all flowers in all positions on a large section of a tree by the most natural agency, namely, the honey-bee. Table I shows that even under abnormally poor environmental conditions self-pollination by bees is quite as effective as that by other commonly used methods. By "brushing" is understood here the application of viable pollen by means of a camel's hair brush and by "bagging", merely the enclosure of flowers in rather large mosquito-bar bags.

TABLE I—SELF-POLLINATION BY BEES VS. SELF-POLLINATION BY BRUSHING AND BY BAGGING

(Weighted average of 7 standard varieties, 1929.)

Method of Pollination	No. of Flowers	Per cent Flowers Set Before June Drop	Per cent Flowers Set After June Drop
By bees...........	8504	1.85	.91
Brushed...........	3579	2.82	1.26
Bagged............	4234	1.75	.97
Open pollinated....	9983	13.09	6.17

It will be noted that, when selfed by bees, the set of flowers was somewhat low, especially after the June drop. Still the differences, due to effects of the cold and rainy weather, are not very marked, if the set of all types of selfed flowers is contrasted with the results secured by open pollination. It is more than likely that the situation will be quite different in a favorable year.

While no figures are given at this time, it may be said that in most cross-pollinations, where effective pollinizers were used, the set of fruit in cages compared quite favorably with sets secured from application of viable pollen by hand to non-emasculated but protected flowers. The cages, of course, greatly facilitated the work, and made the operation far less expensive and less subject to errors coincident with the employment of a large force of assistants.

One of the most important disadvantages to the use of this method of pollination studies is most likely the shading of foliage by the screens. This has been pointed out by several investigators and, of course, was anticipated. Hence the building of all cages in sections, permitting a ready removal of the tops and sides. As pointed out before, this was done in all cases as soon as the fruit had set. Next year, wherever necessary, the cages will be dismantled and transferred to the most desirable bearing trees.

Studies of the extent and nature of the fruit drops are made more convenient and more accurate when the tree or a representative part of it is confined within a cage. There is no interference from

windstorms. Moreover, any possible effects of the pollen parent on the seasonal distribution of drops may be readily determined. In this particular investigation drops in all cages were carefully counted and representative samples taken for microscopic observation of the development of embryos.

The following major conclusions are drawn from the first year's work: There are three, and possibly four, waves of shedding of im-

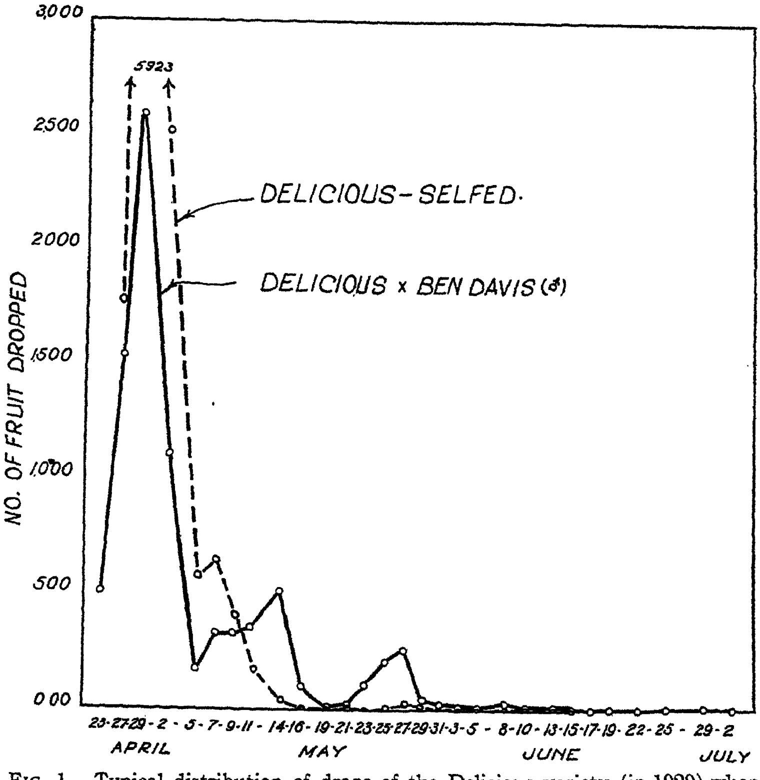


FIG. 1. Typical distribution of drops of the Delicious variety (in 1929) when selfed and when cross-pollinated.

mature fruits. The first is the most pronounced and often of a compound character. Self-pollinated flowers drop soon after flowering, in one large wave. The subsequent drops of fruits are comparatively small. Cross-pollinated flowers persist longer than selfed, thus showing the influence of a compatible mating, (considering gametes as mates) and the presence of vigorous embryos. The first shedding is followed by a second, a third, and a fourth, at fortnightly intervals, as shown in Fig. 1. The shedding performance is primarily a variety characteristic. Most likely it is determined by the genetic constitution of the variety and hence is deep seated and hereditary. It is

influenced only to a limited extent by the pollen parent, thus supporting the results secured by Detjen (1, 2).

All varieties considered produced fewer fruits, containing approximately one-half as many seeds when self-pollinated as when cross-pollinated. There was, however, very little difference in the average weight of the fruit at maturity. Size of apples is determined primarily by the food supply (5), which in turn is a function of the leaves. Selfed sectors of trees naturally carried less fruit, which, though containing few seeds, were drawing on an ample food supply. But whether self or cross-fertilized, fruit with a small number of seeds drop more readily at or near harvest time.

Considering the results of the past three years, it is very evident that Delicious, Ben Davis, and Jonathan are the three outstanding pollenizers for most commercial varieties of apples in Missouri.

Literature Cited

1. Detjen, L. R. Physiological dropping of fruit. Del. Agr. Exp. Sta. Bul. 143. 1926.
2. ———— and Gray, G. F. Physiological dropping of fruit. II. In regard to genetic relationship of plants. Del. Agr. Exp. Sta. Bul. 157. 1928.
3. Howlett, F. S. Apple pollination studies in Ohio. Ohio Agr. Exp. Sta. Bul. 404. 1927.
4. MacDaniels, L. H. An evaluation of certain methods used in the study of the pollination requirements of orchard fruits. Mem. Hort. Soc., N. Y., 3:139. 1927.
5. Sax, K. Studies in orchard management. II. Factors influencing fruit development of the apple. Maine Agr. Exp. Sta. Bul. 298. 1921.

Further Evidence of the Variability of Apple Pollen as Determined by the Spur-Unit Method.*

By S. W. WENTWORTH, *University of Maryland, College Park, Md.*

WITHIN recent years considerable interest has developed among fruit growers and investigators concerning the factors which influence set of fruit. The importance of many factors has been clearly established; many other factors still offer a fertile field for investigation. In a previous paper (2) evidence was presented indicating that different samples of Rhode Island Greening pollen may vary rather markedly in potency when used as pollenizers for McIntosh. Further evidence of the variability of apple pollen is presented in this paper.

VARIATION IN RHODE ISLAND POLLEN

Pollen was obtained from five Rhode Island Greening trees each growing in a different orchard at Ithaca, New York. For simplicity, the name of the orchard in which each tree was growing will be used in designating the different trees, namely:

Kimball Rhode Island, 26 years old, consistently vigorous and heavy bearing, has been in clean cultivation on one side and sod on the other. It had a heavy bloom in 1929.

Extension Rhode Island, 6 years old, exceptionally vigorous with a twig growth of about 30 inches in 1929, is in clean cultivation with cover crops. It had a medium bloom in 1929 and no bloom previously.

Mead Rhode Island, 8 years old, ringed severely in 1925, entirely neglected for the past 4 years, is growing in sod and has an annual twig growth of two to four inches. It had a medium bloom in 1929.

Washburn Rhode Island, 12 years old, very vigorous with an annual twig growth of about twenty-five inches, has been growing under a sod mulch system. It produced no flowers in 1928 but bloomed heavily in 1929. This tree received an application of 10 pounds of $NaNO_3$ on April 17, three weeks previous to the opening of the flowers. On the same date several small branches on this tree were ringed. Pollen was gathered from the ringed and unringed portion of the tree three weeks later. This pollen will be referred to as Washburn Rhode Island ringed and Washburn Rhode Island nitrated.

Eight vigorous, 13-year-old McIntosh trees, selected for uniformity from a large block maintained under clean cultivation and cover crops in the Cornell orchards, were used as female parents. During the bloom period, May 6 to 19, there were 80 hours of sunshine. The maximum daily temperature for the period ranged from 50 degrees to 73 degrees F. and the minimum temperature for the period was 30 degrees F. on May 10. Although the season was very cool, bees flew in sufficient abundance during the receptive period to cause the heaviest crop of fruit that the trees have ever produced.

*The data presented in this paper were obtained by the writer while working under the direction of Dr. A. J. Heinicke, Cornell University, Ithaca, New York.

The technique used was essentially the same as that described by Wentworth, Furr, and Mecartney (1) with slight modifications. Beginning on May 1, when the flower buds were separating in the clusters, approximately 75 vigorous spurs were selected on each of the 8 McIntosh trees. Considerable care in selecting spurs was necessary since many of the clusters showed pistil injury to one or more of the flowers. This injury was apparently caused by cold weather which occurred during the cluster-bud stage. It was most severe on the weak spurs. The terminal flowers and the most advanced laterals also showed the greatest amount of injury. The most vigorous normal lateral flowers of the selected spurs were tagged as indicated below and left unbagged to develop normally. On May 6, just before the lateral flowers on the most advanced spurs were ready to open, the spurs were bagged with transparent "Glassine" paper bags. On May 7, 8, and 10, when the pistils were in a receptive condition, the spurs were thinned to the desired number of lateral flowers and pollinated in the following manner:

Series A, consisting of approximately 23 spurs on each tree, with the pollen from Kimball, McGowan, Extension and Meade Rhode Island trees competing on the four lateral flowers of each spur.

Series B, consisting of approximately 22 spurs on each tree, with the pollen from Washburn ringed, Washburn nitrated, Extension and Mead Rhode Island trees competing on the four lateral flowers of each spur.

Series C, consisting of approximately 20 spurs on each tree with the pollen from Washburn ringed, and Washburn nitrated, competing on two lateral flowers of each spur.

Presentation of Results

TABLE I—Comparative Effectiveness of Pollen from Different Rhode Island Trees on McIntosh

Series A

McIntosh Trees ♀ Parents	Number of Flowers Pollinated	Per cent Set June 1, 1929. Rhode Island Pollen.			
		Kimball	McGowan	Extension	Mead
KH20	24	8.3	4.2	0.0	8.3
KH19	20	15.0	25.0	35.0	15.0
KH12	28	21.4	3.6	3.6	3.6
KI10	24	16.7	8.3	4.2	8.0
KG8	24	25.0	0.0	12.5	0.3
KH7	26	19.2	19.2	19.2	11.5
KJ13	18	22.2	27.8	5.6	11.1
KJ18	19	26.3	5.3	0.0	5.3
Average Per cent Set*		19.1±1.4	10.9±2.6	9.8±2.9	7.6±1.2
No. Mature Fruits		24	11	11	9
Av. Wt. Fts. (gm.)		116.7±3.0	110.5±4.1	106.0±4.9	119.9±6.1
Av. No. Mature Seeds		2.7±0.17	1.7±0.18	3.3±0.59	2.6±0.26

Series B

McIntosh Trees ♀ Parents	Number of Flowers Pollinated	Per cent Set June 1, 1929. Rhode Island Pollen.			
		Washburn Ringed	Washburn Nitrated	Extension	Mead
KH20	26	3.8	11.5	0.0	11.5
KH19	21	42.9	42.9	4.8	4.8
KH12	21	23.8	9.5	9.5	0.0
KI10	24	29.2	33.3	20.8	8.3
KG8	22	13.6	13.6	9.1	9.1
KH7	24	29.2	16.7	4.2	16.7
KJ13	22	27.3	31.8	4.5	9.1
KJ18	17	5.9	5.9	23.5	11.8
Average Per cent Set*		22.0±3.2	20.9±3.2	9.0±2.0	9.0±1.2
No. Mature Fruits		31	28	11	11
Av. Wt. Fruits (gm.)		115.2±2.3	114.4±3.3	118.6±3.4	116.7±5.3
Av. No. Mature Seeds		3.0±0.2	2.9±0.2	2.8±0.3	2.6±0.3

Series C

McIntosh Trees ♀ Parents	Number of Flowers Pollinated	Per cent Set June 1, 1929. Rhode Island Pollen		
		Washburn Ringed	Washburn Nitrated	
KH20	21	4.8	23.8	Two flowers pollinated on each spur
KH19	19	42.1	36.8	
KH12	20	30.0	25.0	
KI10	22	22.7	18.2	
KG8	19	15.8	15.8	
KH7	19	15.8	10.5	
KJ13	20	15.0	30.0	
KJ18	20	25.0	25.0	
Average Per cent Set*		21.2±2.7	23.1±2.0	
No. Mature Fruits		25	31	
Av. Wt. Fruits (gm.)		114.8±3.5	118.5±2.8	
Av. No. Mature Seeds		3.3±0.2	3.2±0.2	

*Weighted average.

Table I presents a summary of the results obtained. In Series A it is apparent that the pollen from the Kimball Rhode Island tree caused a significant increase in the set of fruit as compared to that obtained from the other three trees. The set obtained from the three latter trees, however, show no significant differences.

In Series B there was apparently no significant difference in the set obtained from the pollen from the ringed and that from the ni-

trated portion of the Washburn Rhode Island tree. The pollen from both portions of this tree, however, caused a significant increase in the set as compared to that obtained with pollen from the Extension and Mead Rhode Island trees.

In Series C pollen from the ringed portion and pollen from the unringed nitrated portion of the Washburn Rhode Island tree competed on the same spurs. In this case it is clear that there was no significant difference between the two samples of pollen, the difference in set being well within the experimental error.

The number of mature fruits obtained from each pollen sample should be a very good index of the potency of the pollen. In this respect the pollen samples from the Kimball and Washburn trees were from 2.2 to 2.8 times as effective as the pollen samples from the other three trees. There appears to be no significant differences in the average weight of the mature fruits, however, or in the average number of mature seeds in the fruits.

Variation in the Baldwin Pollen

Samples of pollen were also gathered from four different Baldwin trees growing in the Ithaca orchards, namely: Kimball Baldwin, a tree 26 years old, moderately vigorous and productive, growing in the open with clean cultivation on one side and sod on the other and receiving moderate pruning. This tree was in its fruiting year and bloomed heavily.

A-A-7 Baldwin, a tree 18 years old in the Station orchard, exceptionally vigorous, growing under a system of heavy pruning, clean cultivation and cover crops. This tree bloomed moderately.

McGowan Baldwin, a tree 35 years old with an annual terminal growth of about four inches, growing under clean cultivation and nursery crops, but having received no pruning or spraying for the past ten years. This tree was decidedly in its off year, the only flowers produced being used for the sample.

Washburn Baldwin, a tree 12 years old, under sod mulch with a very weak growth due to borer injury. The tree bloomed full in 1929 but set poorly and produced small leaves and fruit.

Five vigorous 18-year-old Rhode Island trees were selected as female parents to test the variability of samples of pollen from the Baldwin trees. On May 16 and 17 the Rhode Island flowers were tagged and pollinated in such a manner as to permit the different samples of pollen to compete on the same spurs as previously described. Conditions for testing any differences in the samples seemed excellent, for the spurs were very vigorous, the stigmas of the flowers were glistening and the samples of Baldwin pollen were well dehissed and in excellent condition.

Results

Table II shows the number of flowers on each tree pollinated with each pollen and the percentage set on June 3, just previous to the June drop. It is clear that pollen from three out of four of the Baldwin trees was completely incompatible with the five Rhode Island trees, while pollen from the McGowan Baldwin set a fair percentage of the fruits on three trees in series D and on two trees in series E.

TABLE II—VARIATION IN POTENCY OF BALDWIN POLLEN ON RHODE ISLAND

Rhode Island Trees ♀ Parents	Per cent Set from Each Pollen, June 3, 1929							
	Series D					Series E		
	Flowers Pollinated	Baldwin Pollen				Flowers Pollinated	Baldwin Pollen	
		Kimball	A–A–7	McGowan	Washburn		McGowan	Washburn
AH9	25	0.0	0.0	0.0	0.0	16	0.0	0.0
AH7	25	0.0	0.0	8.0	0.0	16	12.5	0.0
AH6	25	0.0	0.0	15.0	0.0	16	6.2	0.0
AH4	25	0.0	0.0	15.0	0.0	16	0.0	0.0
AG8	25	0.0	0.0	0.0	0.0	16	0.0	0.0
Average per cent Set		0.0	0.0	7.6	0.0		3.7	0.0

approaching the conditions obtained when an entire tree is tented than the individual cluster method.

The cheese-cloth bags, 3 feet by 6 feet were placed over the limbs a few hours before the first terminal flowers opened, and were removed just as the petals had fallen. The hand self-pollination of the enclosed flowers was usually carried out just as the anthers began to shed the pollen abundantly. The cross-pollination was done at the same time. No emasculation was carried out, as the author has obtained further data (yet unpublished) indicating the undesirability of emasculation whenever it can be avoided.

On all the limbs *entirely* selfed, and on some of those *entirely* cross-pollinated, practically all flowers of the individual clusters were used. On the remainder of the limbs upon which some cross-pollination was done, only one flower of a cluster was pollinated. On certain limbs the clusters were divided into three sets. The first cluster had all four lateral flowers selfed; the adjacent cluster had two laterals selfed and the remaining two selfed; while the last cluster had all flowers crossed. On certain other limbs, a cluster entirely selfed was followed by a cluster entirely crossed, and so on along the limb. With the above arrangements of selfed and crossed flowers, all possible combinations were included under the one cheese-cloth bag.

The data from these experiments are still presented in part on the basis of percentage of flowers setting fruit. The count of fruits set was taken just after what is commonly called the first drop, and again after all dropping had ceased. The following data were also taken from the self-, open-, and cross-pollinated limbs, namely, total number of flowering points, total number of growing points (including flowering points) total number of flowers, and total number of fruiting points after the first drop and after all dropping had ceased. The number of fruits to a fruiting point after each drop, was also included. The open and hand cross-pollinated limbs were thinned to six inches whenever desirable and the number of fruits remaining were counted. The data presented in Table II show part of such data for certain limbs of several of the varieties. The most significant data in this table are those in the last two right-hand columns, that is, the ratio of fruiting points to the total number of growing points (including flowering points) both after the last drop, and also, after thinning.

Presentation of the Data

In the first place, the very small percentage of set (Table II) obtained from selfing all varieties, exclusive of Rome Beauty and Gallia Beauty, was unquestionably less in each case than the requirement for a commercial crop. The highest percentage set obtained from Baldwin was 2.5; Grimes Golden, 1.4; Jonathan, 2.9; McIntosh, 0.3; Stayman Winesap, 0.5; and Yellow Transparent, 0.2. Delicious produced no fruits from selfed clusters after the last drop.

Gallia Beauty and Rome Beauty produced percentage sets within the range which might be expected to be sufficient for a satisfactory commercial crop. The highest percentage obtained with Gallia Beauty was 8.2 while Rome Beauty reached 8.0 per cent.

TABLE I—SELF-POLLINATION EXPERIMENTS AT WOOSTER, 1928–1929

Tree and Limb No.	Treatment of Limb	Pollen Variety	No. of Flowering Points	No. of Flowers	Percentage of Flowers Setting Fruit: After 1st Count	After 2nd Count	After Thinning
	Baldwin, 1928						
359–1	selfed	Baldwin	42	162	3.7	1.9	
2	clusters selfed	Baldwin	20	95	0.0	0.0	
	clusters crossed	Jonathan	18	79	13.9	7.6	
3	clusters selfed	Baldwin	39	165	7.2	2.5	
	clusters crossed	Jonathan	39	165	23.8	7.8	
4	clusters						
	half selfed	Baldwin	50	100	3.0	0.0	
	and crossed	Jonathan	50	100	34.0	23.0	
5–12	open-pollinated		225	1129	44.2	11.1	8.1
	Baldwin, 1929						
395–1	selfed	Baldwin	56	208	5.8	1.4	
2	clusters selfed	Baldwin	14	51	0.0	0.0	
	clusters						
	half selfed	Baldwin	13	22	0.0	0.0	
	and crossed	Jonathan	13	22	36.4	31.8	
	clusters crossed	Jonathan	17	58	44.8	22.4	
3	open-pollinated		207	984	40.2	14.6	7.5
4	open-pollinated		191	917	44.6	8.9	5.4
84–1	selfed	Baldwin	78	251	0.0	0.0	
2	clusters selfed	Baldwin	29	106	0.0	0.0	
	clusters						
	half selfed	Baldwin	26	48	2.1	2.1	
	and crossed	Jonathan	26	48	25.0	25.0	
	clusters crossed	Jonathan	23	81	11.1	11.1	
3	clusters selfed	Baldwin	23	99	0.0	0.0	
	clusters						
	half selfed	Baldwin	23	42	0.0	0.0	
	and crossed	Jonathan	23	42	35.7	32.8	
	clusters crossed	Jonathan	25	91	21.0	18.7	
4	selfed	Baldwin	38	38	0.0	0.0	
5–7	open-pollinated		240	976	2.0	1.7	
83–1	selfed	Baldwin	68	290	1.7	0.7	
2	open-pollinated		150	760	11.2	4.7	4.7
	Delicious, 1929						
279–1	selfed	Delicious	213	786	0.5	0.0	
2	crossed	Gallia	143	143	46.1	0.0	
3	crossed	Grimes	87	87	77.0	12.6	
4	crossed	Jonathan	42	42	21.4	0.0	
5	crossed	Jonathan	88	88	34.1	0.0	
6	open-pollinated		68	275	26.9	15.6	13.1
	Gallia Beauty, 1929						
4–1	selfed	Gallia	86	366	20.0	8.2	
2	crossed	Rome	63	287	6.6	0.8	
3	crossed	Red Spy	32	197	44.7	16.7	13.2
4	crossed	Jonathan	41	154	29.1	13.6	11.1
5	open-pollinated		84	481	43.0	15.4	12.0
	Grimes Golden, 1928						
410–1	selfed*	Grimes	179	805	0.0	0.0	
2	selfed*	Grimes	191	864	0.0	0.0	
3	open-pollinated		134	757	45.0		

*Not hand self-pollinated

TABLE I—*Continued*

Tree and Limb No.	Treatment of Limb	Pollen Variety	No. of Flowering Points	No. of Flowers	Percentage of Flowers Setting Fruit: After 1st Count	Percentage of Flowers Setting Fruit: After 2nd Count	Percentage of Flowers Setting Fruit: After Thinning
		Grimes Golden, 1929					
410–1	selfed	Grimes	156	671	1.8	1.4	
2	clusters selfed	Grimes	28	107	3.7	0.9	
	clusters half selfed	Grimes	34	62	8.1	0.0	
	and crossed	Jonathan	34	62	85.5	48.4	
	clusters crossed	Jonathan	33	122	63.1	22.1	
3–4	open-pollinated		419	1662	62.6	19.0	13.5
		Jonathan, 1928					
408–1	selfed	Jonathan	186	662	5.6	2.9	
2–4	open-pollinated		312	1679	34.7	11.3	8.8
		Jonathan, 1929					
408–1	selfed	Jonathan	225	908	0.3	0.0	
2	clusters crossed	Gallia	180	604	31.3	11.9	6.2
3	open-pollinated		308	1520	31.4	4.3	
		McIntosh, 1929					
338–1	selfed	McIntosh	138	670	1.5	0.3	
2	crossed	Baldwin	86	165	3.6	0.0	
3	crossed	Gallia	105	194	49.0	6.6	
4–5	open-pollinated		321	1641	31.2	3.6	
		Rome Beauty, 1928					
430–1	selfed	Rome	111	500	19.2	8.0	7.4
2	crossed	Gallia	68	306	0.0	0.0	
3	open-pollinated		82	451		12.4	11.1
		Rome Beauty, 1929					
325–1	selfed	Rome	127	651	2.0	1.7	
2	crossed	Golden Delicious	105	105	41.9	16.2	
3	open pollinated		108	791	20.9	5.1	
		Stayman Winesap, 1929					
158–1	selfed	Stayman	108	370	2.1	0.5	
2	crossed	Delicious	61	61	21.3	8.2	
3	crossed	Gallia	69	69	23.2	13.0	
4	crossed	Grimes	99	99	16.1	12.1	
5	crossed	Jonathan	87	87	19.5	12.6	
6–7	open-pollinated		448	1639	14.4	8.7	8.2
811–1	crossed	Delicious	92	92	25.0	20.6	
2	crossed	Jonathan	115	115	13.9	13.0	
3–6	open-pollinated		248	1112	3.8	2.7	
		Wealthy, 1928					
291–1	selfed	Wealthy	68	312	3.5	1.9	
2	clusters selfed	Wealthy	55	244	6.9	4.1	
	and crossed	Jonathan	54	188	19.7	11.2	
3–6	open-pollinated		393	1694	20.6	10.5	
		Yellow Transparent, 1928					
83–1	selfed	Yell. Trans.	*104	530	3.4	0.2	
2	clusters selfed	Yell. Trans.	26	104	10.6	1.0	
	clusters half selfed	Yell. Trans.	29	58	0.0	0.0	
	and crossed	Delicious	29	58	39.6	36.2	
	clusters crossed	Delicious	29	116	55.2	44.8	
3–9	open-pollinated		329	1630	62.3	29.5	13.1

*Not hand self-pollinated.

When the data in Table II are considered, there appears to be a greater difference between the fruits produced from selfing and those required for a commercial crop, than is evident from a comparison of the percentages in Table I. In the first place no self-pollinated limbs of any variety had sufficient fruits for a commercial crop. Gallia Beauty and Rome Beauty as indicated by the data in Table II were much closer, however, to a commercial crop than any other variety. Baldwin, for example on limb 1 of tree 359, produced 1.9 per cent set from selfed flowers. This represented one fruiting point for every 45 growing points, including flowering points; while on the open pollinated limbs, one fruit to seven growing points was required for a commercial crop. Jonathan tree 408 in 1928 produced 2.8 per cent set from the selfed limb which represented one fruiting spur to 25 growing points. The open-pollinated adjacent limb required one fruit for every seven growing points for a commercial crop. Rome Beauty tree 430 in 1928 with its 8.5 per cent set from the selfed limb represented one fruiting point to every 9 growing points. The open pollinated limb after thinning had one fruiting point to every four growing points.

TABLE II—Comparison of Number of Spurs Fruiting Under Self- and Open-Pollination Conditions at Wooster, 1928–1929

Variety of Pollen	Total No. of Spurs	Per cent Spurs		Per cent Flowering Points Fruiting After All Dropping Had Ceased	Ratio of Fruiting Points to Total Number of Spurs	
		Non-Flowering	Flowering		After Last Drop	After Thinning
		Baldwin 359, 1928				
Baldwin	135	69.9	31.1	7.1	1:45	
Open-pollinated	1127	69.0	31.0	55.3	1:6.1	1:6.6
		Baldwin 395, 1929				
Baldwin	200	72	28	5.4	1:66.7	
Open-pollinated	220	6	94	45.9	1:1.2	1:3.0
		Gallia Beauty 4, 1929				
Gallia	89	3.4	96.6	27.9	1:3.7	
Open-pollinated	99	15.2	84.8	69.0	1:1.3	1:1.7
		Grimes Golden 410, 1929				
Grimes	163	4.3	95.7	4.5	1:23.3	
Open-pollinated	485	13.6	86.4	63.7	1: 1.8	1:2.2
		Jonathan 408, 1928				
Jonathan	486	62.8	38.2	10.2	1:25.6	
Open-pollinated	1073	71.9	29.1	47.4	1: 7.2	1:7.2
		Rome Beauty 430, 1928				
Rome	337	66.8	33.2	30.0	1:9.1	
Open-pollinated	206	61.2	39.8	61.0	1:4.1	1:4.1
		Yellow Transparent 83, 1928				
Yellow Transp'r'nt	109	0.5	95.5	1.0	1:109	
Open-pollinated	692	52.5	47.5	70.0	1: 3.0	1:3.3

The varieties Delicious, McIntosh, and Stayman produced fewer fruits from selfing than other varieties. The high percentage sets from crossing both Delicious and Stayman were obtained by using

only one flower to a cluster. The crossed fruits of Delicious, however, fell off during the second drop from all limbs but the one-pollinated by Grimes Golden which was at the top of the tree. The author has previously emphasized (5) the importance of high vigor if even cross-pollinated fruits of Delicious are not to abscise.

The data for McIntosh show a very heavy late drop from the cross-pollinated clusters. This represents what commonly occurs on McIntosh trees in Ohio. Baldwin was an inadequate pollenizing variety. It is to be recalled that Vinson in 1923 (3) obtained only a very small percentage set upon a Stayman Winesap tree when enclosed under a frame with a Baldwin tree and a hive of bees. This hardly lends support to the suggestion that trees of Baldwin and McIntosh interplanted, would produce different results from those obtained by cross-pollinating single limbs.

As suggested in a previous paper (2) as satisfactory results should be obtained from cross-pollinating one flower of a Stayman Winesap cluster as from cross-pollinating all. The data in Table I obtained from pollinating only one flower of a cluster support this conclusion. This emphasizes the importance of high vigor for satisfactory fruit setting of Stayman Winesap even when all flowers are adequately cross-pollinated (2).

Conclusions

The pollination work at the Experiment Station covering now a period of seven years, permits certain conclusions which would be unjustifiable if drawn from a single year's work.

In the first place it has become clear that all the varieties when selfed may be expected to produce a few fruits provided a sufficiently large number of flowers are pollinated. The number produced will likely be larger if the cheese-cloth-bag or entire-tree methods are used.

In the second place these varieties appear to differ in their degree of self-fruitfulness. On the one hand are those which, as far as the evidence now available can be interpreted, have the lowest degree of self-fruitfulness. Varieties included in this group are McIntosh, Rhode Island Greening, Stayman Winesap, Delicious, and Winesap. In an intermediate group with higher degrees of self-fruitfulness, the writer would place Jonathan, Grimes Golden, Oldenburg, Wealthy, Baldwin, and Yellow Transparent. Finally there is a third group with higher degrees of self-fruitfulness than those of the second, including Rome Beauty and Gallia Beauty.

As far as the work in Ohio is concerned, only the varieties in the latter group possess degrees of self-fruitfulness sufficiently high to be considered satisfactory, by some, for a commercial crop. Upon the basis of our present information, the writer hesitates to recommend the planting of Gallia Beauty and Rome Beauty in solid blocks.

There is considerable evidence other than that given in this paper supporting the separation of these varieties into three groups. MacDaniels (6) and Chandler (1) have pointed out that Rhode Island Greening and McIntosh fail to set fruit under conditions where Wealthy and Baldwin produce fair crops. Whitehouse and

Auchter (7) have shown the very low degree of self-fruitfulness of Delicious. Stayman Winesap, and its related varieties have been shown by much experimental work to have a similar low degree. Space does not permit a summary of the pollination literature which justifies the inclusion of specific varieties such as Baldwin, Jonathan, and Wealthy in the intermediate group. Such evidence has been summarized by the author in the bibliography of another publication (3).

It is to be observed that the varieties with the lowest degrees of self-fruitfulness are those which are gradually becoming known as light-setting varieties. The writer has suggested (2, 5) that several of these varieties may have abnormalities in chromosome behavior which are in part responsible for low sets of fruit from self-pollinated flowers. Evidence has already been obtained that irregularities are present in the reduction divisions of the megaspore mother cells in Stayman Winesap.

Literature Cited

1. Chandler, W. H. Fruit growing. Houghton-Mifflin Co. 1925.
2. Howlett, F. S. Some factors of importance in fruit setting studies with apple varieties. Proc. Amer. Soc. Hort. Sci., 23 (1926):307. 1927.
3. Howlett, F. S. Apple pollination studies in Ohio. Ohio Agr. Exp. Sta. Bul. 404:1–84. 1927.
4. Howlett, F. S. Further self- and cross-pollination experiments with the Baldwin apple. Proc. Amer. Soc. Hort. Sci., 24(1927):105. 1928.
5. Howlett, F. S. Fruit setting of the Delicious apple. Proc. Amer. Soc. Hort. Sci., 25(1928):157. 1929.
6. MacDaniels, L. H. Pollination Studies in New York. Proc. Amer. Soc. Hort. Sci., 25(1928):129. 1929.
7. Whitehouse, W. E., and Auchter, E. C. Cross-pollination studies with the Delicious apple. Proc. Amer. Soc. Hort. Sci., 23(1926):157. 1927.

Some Facts Concerning Productivity of Irrigated Seed Potatoes

By H. O. Werner, *University of Nebraska, Lincoln, Neb.*

This paper will appear in the publications of the Potato Association of America.

The Relation Between Embryo-Sac Development and the Set of Fruit in the Apple

By M. J. Dorsey, *University of Illinois, Urbana, Ill.*

APPLE flowers show great extremes in vigor of growth. Even before bloom, variations in vigor which indicate differences in potential fruit production are evident. Preliminary studies with Arkansas (Black Twig), Delicious, Stayman, and Winesap showed that the base of the pedicil in the weaker flowers took on a yellowish cast as early as two or three days after full bloom. In such flowers, the ovules enlarged slowly. In Arkansas and Winesap all of the ovules in some flowers, and some in others, showed a pronounced shriveling or slowing up in growth a few days after opening. The shriveled ovules soon took on a brownish color, which is in marked contrast with the greenish cast of normal growth. It would not be expected that flowers showing such retardation in ovule development would have an equal chance to set as compared with normal flowers, although they have been so regarded in many pollination experiments. The object of this study was to determine to what extent embryo-sac development was affected by these extremes in vigor.

In the spring of 1922, when the writer was connected with the West Virginia Experiment Station, the first material was collected for a cytological study of the embryo-sac development in flowers with these characteristics. This study led to attempts, in the two following years, to increase the proportion of normal ovules and, hence, the set, on trees low in vigor, by pruning, cultivation, nitrate applications, and mulching (Dorsey '25). This report is limited to a study of the embryo sac in flowers differing in vigor of growth.

In the normal flowers the typical embryo sac was found to have eight nuclei. Three successive free divisions of the nuclei, in the cell which functions as the embryo sac, give rise to the egg, or female gamete, flanked by two synergids, the three antipodal nuclei at the chalazal end of the sac, and two endosperm or polar nuclei toward the center. Many variations are found from the typical pattern, however, when the weaker flowers of the cultivated varieties are studied critically. The bearing that such variations have upon the set of fruit was studied specifically in Arkansas and York.

Flowers showing extremes in growth for old trees of Arkansas were collected from three orchards in eastern West Virginia. The first flowers were obtained from the John Miller orchard near Inwood. The trees were about 30 years old, and in need of pruning, although under cultivation. This orchard had been fairly productive, but at the time the material was collected there had been considerably slowing down in growth. The trees in the Thatcher orchard, near Martinsburg, from which material was also collected had considerable more vigor than the Miller trees because of the heavy pruning, nitrating, and cultivation. Some of the trees were growing more vigorously than any others to be found in this region, and the orchard had a good record of production due partly to pollination, since Delicious, York, and Jonathan were available as pollenizers (Auchter and Schrader, 1925). The Crane orchard, near Charles

Town, was in sod and, while receiving occasional light applications of fertilizers, was practically unpruned. Tree growth was slow and, while most of the trees were not blooming, an occasional tree or a limb here and there was blooming and bearing some fruit. Ben Davis and Grimes pollen was available.

In most of the flowers taken at random from the Miller orchard just before receptiveness, the embryo sac was conspicuously narrow. In some embryo sacs eight nuclei were present and apparently normal; in others, there were no more than four or six. Before the stigmas of this variety were receptive, there was evidence of degeneration or suppressed growth, as shown by the dense staining of the nuclei and the embryo sac in general. The nuclei under these conditions were much smaller than in embryo sacs in which growth was more vigorous. Suppression as early as the megaspore mother cell stage was not found in even the weakest flowers.

By the time the petals had fallen from the first flowers in the cluster the stigmas had turned brown, thus marking the end of the receptive period. In those embryo sacs where fertilization had not taken place by that time, degeneration had begun in all nuclei. There was as early as this a complete collapse of the embryo sac in some ovules and an apparent withdrawal of its contents. In these cases the cells of the nucellus immediately surrounding the embryo sac were generally broken down, and there was but little elongation of the sac into the nucellus. These flowers fell at the first drop.

This general condition found in the weaker flowers from both the Miller and Crane orchards showed considerable contrast when compared with the first flowers to open on the stronger spurs (¾ inch long or more) from the Thatcher orchard. Even in the central flowers, which Howlett (1926) found to bear only 2.7 per cent of the fruit after the first drop, many of the embryo sacs reached full development. In the absence of gametic fusion, there was a pronounced shriveling of some of the ovules by the end of receptiveness, but in others, from the top of a tree that had been heavily pruned and nitrated for three successive seasons, some of the embryo sacs appeared normal as late as 8 days after bloom.

There is a wide range, therefore, in the time the embryo sac may remain normal, even in the first flowers. Whether this situation would be changed by early pollination was not determined, but there is clearly an early breakdown of the embryo sac in all except the most vigorous ovules. In addition to providing the necessary cross-pollination for Arkansas, it would seem necessary, in view of the early breakdown of the embryo sac in the weaker flowers, to have a vigorous spur growth with a large leaf area in order to get an adequate set.

York is known in the Shenandoah-Cumberland district as a biennial bearer. The flowers are weak on old trees low in vigor. Counts of the number of spurs setting fruit on this variety with a snowball bloom in the on year showed some trees to set fruit on as low as eight per cent of the spurs which bloomed. With York in the Thatcher orchard, an attempt was made to increase the set on old trees which had in the past borne heavy crops but were then slow

growing and in need of pruning and nitrogen, although under cultivation.

In 1923, material was collected from selected trees of low vigor. At petal fall the central flower from a spur which grew $\frac{1}{16}$ inch the previous season and bearing three small leaves showed, when sectioned, only three nuclei in one embryo sac, while in another four nuclei could be made out in a densely stained mass in the position of the embryo sac. In another terminal flower from a spur of similar vigor, which had bloomed once before in six years, there were five nuclei in one sac but the chalazal end showed a diffused staining reaction. The central flower from a spur ten years old, which had bloomed four times previously, but without maturing a fruit, had only one embryo sac in which the nuclei appeared normal, the others showing the typical short, narrow sac, characteristic of weak spurs. These instances give an index of development in the embryo sac in flowers of the lowest vigor. In such flowers, receptivity does not always seem to occur or, if it does, its duration is limited to two days or so at most.

In line with this general condition is the more localized breakdown of some of the ovules in the stronger growing flowers which show an advanced stage of collapse by the end of receptiveness. It would seem that it would be impossible to obtain a high seed content some seasons with the best of pollination, if the condition found in ovules from even the more vigorous York spurs is typical. Early pollination and fertilization may supply some stimulus, but the effect of these could not be estimated because these flowers were open pollinated. The sections of this material show that the variations in size between the different ovules in a flower, which became so evident a few days after petal fall, furnish a fairly accurate index of the condition within.

In view of this condition, which was found to be typical for weak flowers of this variety, it will be of interest to note briefly the result of an attempt to raise the level of functioning in the embryo sac by cultural treatments. Tree 13-13 in the Thatcher orchard was one of the lowest in vigor selected for this study. In the spring of 1923, this tree was pruned, nitrated, cultivated, and mulched. In pruning the first year, small cuts were made and about one-half of the twigs and spurs were removed. The second year it was necessary to make only a few cuts to thin out and direct the growth. Nine pounds of nitrate of soda were broadcasted under the tree each spring before bloom. A straw mulch approximately six inches thick and extending out to the ends of the branches was applied in May. The remainder of the ground between the trees was cultivated until late July.

The growth response of the tree the first summer after this was interesting. The leaves were large and dark. As a result of the increased space and light from the pruning, spur growth the first season was characterized by thickness rather than length, most of the older spurs laying down a much thicker annual layer than in previous years. As will be seen by referring to Table I, the growth the second year (1924) was much longer than the first, and in spite of the heavy crop of 1923, was well proportioned.

TABLE I—A SUMMARY OF THE GROWTH MEASUREMENTS OF 291 SPURS, OR TWIGS, OF YORK, TAKEN AT RANDOM FROM TREE 13-13 IN THE THATCHER ORCHARD.

Classes in Inches in Which Growths Were Measured	No. of Growths in Each Class for Each Year				
	1921	1922	1923	1924	Total
0.12	181	150	148	48	527
0.25	82	95	98	93	368
0.50	10	16	16	27	69
1.0	16	21	17	38	92
2.0	2	6	7	37	52
3.0		2	2	11	15
4.0		1	2	15	18
6.0			1	11	12
8.0				7	7
10.0				1	1
12.0				2	2
14.0				0	0
16.0				1	1
	291	291	291	291	1164

In the spring of 1925, the annual elongation of 291 growing points, summarized in Table I, was determined for a four-year period. The measurements were taken in this way so that the growth of the two years before the treatment could be compared with that of the two years following. It was surprising to find the growth so slow in such a large proportion of the spurs. Even in 1923 and 1924, after a treatment which included the usual recommendations for this tree condition, a large proportion of the spurs were of average vigor or below, assuming .25 of an inch to be the dividing line for York.

This work, as noted above, was initiated in order to build up a background in which to study embryo-sac development in its relation to the set of fruit. In the spring of 1924, on 450 spurs taken at random from tree 13-13 one fruit had set on 179 spurs; two on 154; three on 87; four on 25; while five was the set on 5 spurs (Dorsey 1925). Assuming that there was ample pollination, this series taken under tree conditions where 96 per cent of the spurs which produced flowers had set fruit, shows gradations comparable to those found in the sectioned material. Unfortunately, the seed content of these fruits was not determined. Sections of ovules from vigorous spurs on tree 13-13 (½ inch long or longer) fixed one week after full bloom show that the egg cell in most of the embryo sacs was normal in appearance as late as this. There were no embryos in the sections studied and in the absence of endosperm nuclei and the presence of only two pollen tubes, which had grown as far as the mycropyle, it would seem safe to conclude that fertilization had not taken place in the sections studied. From this general condition, therefore, it appears that in York, as with Arkansas, embryo-sac development and persistence is closely associated with growth.

A large number of sections were made of the ovules of other varieties. The list includes Ben Davis, Duchess, Yellow Transparent, Willow, Wealthy, Maiden Blush, Delicious, Jonathan, Grimes, Stayman, Rome, and Winesap. There was in these, as with Arkansas

and York, considerable variation in the development and persistence of the embryo sac. Delicious resembled very closely the general situation in Arkansas, and Winesap seemed to be more like York in that weak flowers could be stimulated to set fair crops by good culture. The heavier setting varieties, like Jonathan, Grimes, and Rome, seemed to mature a greater proportion of the embryo sacs in flowers of low vigor than Arkansas or York.

Discussion

The relationship between tree growth and embryo-sac development has been studied by other investigators. Knight (1917) states that in Rome "At 120 hours the egg begins to show disintegration." He apparently did not consider the time of disintegration in relation to flower vigor. Roberts (1926) found that "weaker blossoms have poorly developed embryo sacs, or degenerate embryo sacs in which the egg cells become abortive before fertilization can occur." In Delicious, Howlett (1928) states that "fertilization has probably not occurred in a very large proportion of the ovules of the unenlarged flowers abscissing very shortly after petal fall." He further states that "the enlarged partially developed fruits of the first and second drops show various stages of embryo development in nearly all ovules." The extent of undeveloped ovules in the apple was studied extensively by Crandall (1917) in both commercial varieties and in crab-like forms. His results show that under open-pollinated conditions only 45 to 75 per cent of the ovules form seeds. Considering the loss of flowers from the drops and the extensive suppression of ovules in ripe fruits even when grown under the best cultural conditions, it will be seen that in the apple a large proportion of the ovules may be lost as far as seed production is concerned. This condition is of particular interest to fruit growers in view of the intimate relationship between seed and fruit development (Heinicke 1917) and the difficulty in varieties like Arkansas and York of raising the level of vigor in the flowers when the soil is low in fertility.

The set of fruit may also be influenced by factors other than embryo-sac development. Late pollination resulting from unfavorable weather during bloom or a scant pollen supply with self- or cross-sterile varieties are conditions frequently met with. The significance of having a heavy dissemination of pollen will be evident to anyone who has studied critically the behavior of pollen upon the stigma. When many grains fail to germinate, and others produce only short or slow-growing tubes, with only the occasional grain sending out a tube with sufficient vigor to bring about fertilization, it is evident that the chances of having a larger number of the latter type present increase as the number of grains to reach the stigma increases. The more vigorous seedlings may be looked upon as representing the end result of the series where, in the more vigorous embryo sacs, the egg is fertilized by a gamete from the faster growing pollen tubes.

These studies do not show whether or not fertilization takes place in embryo scas which do not have the full nuclear number. In view of the increased set from early pollinations, it is possible that in those sacs lacking the full complement of nuclei the egg cell is formed

and functional and that the reduced nuclear content results from the failure of some of the other nuclei to divide. Under such conditions the endosperm nuclei may be formed and functional. It is more probable, however, that fertilization, and embryo and endosperm growth, are limited to the more nearly normal sacs, even though their vigor or persistence may be considerably reduced. The increased speed of growth of the pollen tubes in the more vigorous flowers (Roberts 1926) would have an important bearing upon this situation but the other variable—the more vigorous pollen tubes—must also be reckoned with, especially in view of the stimulus to growth from fertilization.

Fundamentally, in the pollen tube and the embryo sac, we are dealing with the relationship between the gametophytic and sporophytic generation. The former is an x structure dependent upon the latter. In either the pollen grain or the embryo sac it would appear that gametic combinations in extremely heterozygous material, such as the apple, might have a far-reaching influence upon normal development. For instance, why, in a background such as the anther sap, which is a nutrient media derived from the sporophyte, do some grains develop normally while others do not? Likewise, in the pistil of the apple with ovules so closely associated and conceivably sharing so directly in the food supply furnished by the sporophyte, why are some embryo sacs in a fruit suppressed while others are not? Or, in the extreme, why are some embryo sacs suppressed early while others persist until even after the period of receptiveness of the stigma? It would appear that with nutrition and genetic constitution as variables we could expect such a series in embryo-sac development and persistence as was found in this material.

Conclusions

Suppression of the embryo sac, as evidenced by a reduced number of nuclei or their early disintegration, takes place in the ovules of the weaker growing flowers even before bloom. With greater tree or spur vigor, the organization of the embryo sac is carried further and persists longer. Consequently, fertilization is impossible in a large but variable proportion of the ovules of apple flowers.

Literature Cited

1. Auchter, E. C., and Schrader, A. L. Cross fertilization of the Arkansas (Mammoth Black Twig) Apple. Proc. Am. Soc. Hort. Sci., 96. 1925.
2. Crandall, C. S. Seed Production in Apples. Ill. Agr. Exp. Sta. Bul. 203. 1917.
3. Dorsey, M. J. Some studies on the fruiting habit of the York Imperial apple. Proc. Am. Soc. Hort. Sci., 172. 1925.
4. Heinicke, A. J. Factors influencing the abscission of flowers and partially developed fruits of the apple (*Pyrus malus* L.). Cornell Agr. Exp. Sta. Bul. 393. 1917.
5. Howlett, F. S. Some factors of importance in fruit setting studies with apple varieties. Proc. Am. Soc. Hort. Sci., 307. 1926.
6. Howlett, F. S. Fruit setting in the Delicious apple. Proc. Am. Soc. Hort. Sci., 143. 1928.
7. Knight, L. I. Physiological aspects of self-sterility of the apple. Proc. Am. Soc. Hort. Sci., 101. 1917.
8. Roberts, R. H. Apple physiology. Wis. Agr. Exp. Sta. Res. Bul. 68. 1926.

Some Recent Results in Sterility Studies*

By H. E. Knowlton, *West Virginia University, Morgantown, W. Va.*

IT is well recognized by research workers that there are varying degrees of apple sterility depending on the variety. York, on the one extreme, seems to be nearly self-fertile under West Virginia conditions, while Winesap and Stayman rarely set any fruit when self-pollinated. Other varieties are intermediate. This partial self-sterility, which is somewhat influenced by weather conditions at bloom and by the nutritional condition of the tree, makes it very difficult to get consistent results when tests of self-fruitfulness are made.

In planning such tests conditions should be made as nearly normal as possible. The enclosing of pollinated flowers by paper bags is undesirable, since they cause abnormal conditions of temperature and humidity. Emasculation by tearing off the whole floral envelope may be detrimental due to its drying effects. Whole trees are enclosed in wire-screened frames in the West Virginia experiments. This type of enclosure seems to have little effect on the temperature, humidity, and light conditions within, and because of this probably gives the tree a more normal environment than any method yet devised. Enclosing bloom in white muslin bags has many advantages and probably few of the bad effects produced by paper bags. This method is now being used at West Virginia where it is not feasible to enclose trees in wired screen frames. The stamens and corolla only are removed in emasculation, so that no cut tissues are exposed to dry out the flower. In order to obviate nutritional influences as much as possible very weak spurs are discarded, and three flowers only on each spur are pollinated. From 300 to 700 flowers are pollinated with each variety of pollen under test to reduce variability. Not only does variability occur between spurs but as shown in Table I, between branches as well. These differences in set are probably due to nutrition though the limbs do not outwardly show that there are differences in internal composition.

TABLE I—Variation in Set of Fruit on Different Limbs of Rome (1929) when Pollenized with Northwestern Pollen (Horticulture Farm)

Limb Number	Number Blossoms Pollenized	Number Blosssoms Set	Per cent Blossoms Set
1	69	2	3
2	21	6	3
3	60	21	35
4	138	12	8
5	79	0	0
6	42	0	0

The variety, Delicious, is one of the most important in West Virginia and consequently is receiving considerable attention as regards its behavior when self-pollinated. Field observations of solid blocks of this variety indicate that it is partly self-fertile

*Published with the approval of the Director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 81.

although it fails, under most conditions, to set enough for a commercial crop. Controlled pollinations as shown in Table II, however, result in no set whatever when selfed. This is in agreement with results secured elsewhere. This table also shows that Stayman will not fertilize Delicious, but that York, Grimes, and Golden Delicious are good pollenizers for it. It is now a well established fact that the varieties Stayman, Winesap, and Mammoth Black Twig are not only self-sterile but of little value as pollenizers for other varieties because of the impotent pollen they produce.

TABLE II—SET OF FRUIT ON DELICIOUS (1928) AFTER FIRST DROP (HORTICULTURE FARM)

Pollenizer	Number Blossoms Pollenized	Number Blossoms Set	Per cent Blossoms Set
York	572	139	24
Grimes	461	112	24
Golden Delicious	737	251	34
Stayman	416	0	0
Delicious	460	0	0

Whitehouse and Auchter (1) have mentioned that Delicious is sensitive to abnormal environmental conditions in that few fruits set in paper bags. It should, therefore, be noted that in 1928 weather conditions at bloom were extremely favorable as regards temperature, humidity, and light. A similar pollination experiment was performed in 1929 under unfavorable weather conditions. Practically no set was secured with Transparent, Northwestern, Jonathan, King David, and York used as pollenizers. Howlett (2) has pointed out the value of exceptional spur vigor in setting with this variety and has suggested that possibly another factor which finds expression in abnormalities in embryo development may be operating. The work of Haber (3) supports this view.

The variety Rome ranks second in importance in West Virginia. It has been considered by most investigators to be self-fertile or partially so (4). Field observations support this view, since there are large solid blocks in the Ohio Valley section of the state which set fairly good crops of fruit. Controlled pollinations, however, do not substantiate this. Data taken in 1928 and 1929 are shown in Tables III and IV.

These tables also show that Delicious, York, Grimes, Golden Delicious, Northwestern, Transparent, and Jonathan are good pollenizers, while Stayman and King David seem to be poor pollenizers for Rome. It must be admitted that field observations are untrustworthy evidence upon which to base conclusions regarding the self-sterility of any particular variety because of the inability to measure the cross pollinating work done by bees. It is quite possible that with favorable weather conditions bees will adequately cross-pollinate varieties one-half to a mile apart. The number of active bees and the length of favorable pollinating season are also important factors.

The color sports that have originated in recent years promise to super-

sede the varieties from which they have sprung. These strains should be investigated as regards their sterility and their value as pollenizers for other varieties ascertained. One would naturally expect them to be inter-sterile with the varieties from which they were derived.

TABLE III—SET OF FRUIT ON ROME IN 1928 (HORTICULTURE FARM)

Pollenizer	Number Blossoms Pollenized	Number Blossoms Set		Per cent Blossoms Set	
		May 26	July 1	May 26	July 1
Delicious	510	441	48	86	9.4
York	611	357	44	58	7.2
Grimes	546	352	51	64	9.3
Golden Delicious	539	236	34	44	6.3
Stayman	489	8	0	2	.0
Rome	496	5	3	1	.6

TABLE IV—SET OF FRUIT ON ROME IN 1929 AFTER FIRST DROP (HORTICULTURE FARM)

Pollenizer	Number Blossoms Pollenized	Number Blossoms Set May 14	Per cent Blossoms Set
Northwestern	409	41	10
Transparent	456	69	15
Jonathan	545	37	7
King David	365	9	2.5
Rome	411	0	0

A limited amount of work was done this year (1929) with Gallia Beauty (Red Rome) pollen. Several hundred pollinations were made using this kind of pollen on Rome. The bloom were enclosed in muslin bags instead of enclosing the tree in wire screened cages. An unexpectedly high percentage of set was secured. Howlett (5) published results obtained by pollinating Rome with Gallia Beauty, but since the numbers used in the cross were so small no conclusions can be drawn. It is possible that Howlett did not have the same sport as was used in the West Virginia test since at least three color sports have originated from Rome. The only possible flaw in the West Virginia experiments was in the pollen source. Because no Red Rome were blooming on the Experiment Station farm, pollen was sent in by a reputable grower who has a considerable number of bearing trees of this variety. It is possible, though not probable, that he gathered pollen from the wrong trees. The test will be repeated this year and greater attention will be given to the pollen source.

LITERATURE CITED

1. WHITEHOUSE, W. E., and AUCHTER, E. C. Cross pollination studies with the Delicious apple. Proc. Am. Soc. Hort. Sci., 23:157. 1926.
2. HOWLETT, F. S. Fruit setting in the Delicious apple. Proc. Am. Soc. Hort. Sci., 25:143. 1928.
3. HABER, E. S. Pollination studies with Jonathan and Delicious. Iowa State Hort. Soc. Rep., 58:154. 1923.
4. AUCHTER, E. C. Apple pollen and pollination studies in Maryland. Proc. Am. Soc. Hort. Sci., 18:51. 1921.
5. HOWLETT, F. S. Apple pollination studies in Ohio. Ohio Agr. Exp. Sta. Bul. 404. 1927.

Pollination Studies with the McIntosh Apple in the Champlain Valley Fruit District

By L. H. MACDANIELS and A. B. BURRELL, *Cornell University, Ithaca, N. Y.*

IN the Champlain Valley fruit district of New York State, McIntosh, the leading variety, has in many instances been planted in solid blocks without provision for cross-pollination. In years such as 1926 and 1928, when cool, rainy weather obtained during the blossoming period, partial crop failures have resulted for no obvious reason other than a lack of cross-pollination. Since information was meagre concerning the value of some of the varieties grown in that region as pollenizers for McIntosh, and since the importance of cross-pollination was not fully appreciated by many Champlain Valley growers, these studies were undertaken.

The main objects of the studies were first, to test the effectiveness of the pollen of different varieties in causing McIntosh to set fruit, and second, to provide local demonstrations of the value of cross-pollination. In addition, however, some information was obtained concerning the distance over which pollenizers are effective in a favorable year, the ability of Fameuse to set fruit with its own pollen and the effect on yield of an excessive amount of pollination.

For nearly all of the work, the branch-unit method previously described (1) was used. Uniform branches about an inch in diameter were selected, and when most of the blossoms were open, pollen of the desired variety, previously collected and dried, was brushed onto the stigmas of two or three blossoms of each cluster. Where it was desired to compare the effectiveness of different pollens, a cheesecloth bag, 3x6 feet, covered the branch from the time when the most advanced blossoms were in a full pink stage until after petal fall to prevent insect visitation. Where it was desired merely to determine whether a lack of cross-pollination was limiting the set, the branches were exposed to natural agencies throughout.

The weather during bloom in 1929 in the Champlain Valley was exceptionally favorable for natural agencies to effect pollination The maximum temperatures reached during the six days when the trees were in bloom were 81, 86, 86, 93, 85, and 76 degrees, respectively. The days were sunny with almost no wind, and large numbers of bees were observed working in all orchards. Many of the larger growers brought bees into their orchards for pollination purposes and some made use of pollen bouquets.

RESULTS

The effectiveness of the pollen of different varieties applied to the blossoms of bagged McIntosh branches is indicated in Table I. The data are given in full in a way that makes possible an evaluation of results in terms of other factors than percentage of set. A discussion of this method of presenting pollination data has been previously given (1). In this table, the percentage of blossoming spurs with fruit on August 26 is a good indication of the effective-

TABLE I—POLLINATION RESULTS WITH MCINTOSH IN THE CHAMPLAIN VALLEY, NEW YORK, SPRING OF 1929.

Orchard and Tree Number	Branch Number	Protection from Insects	Pollen Variety	Circum. of Branch in Inches	Total Number of Spurs	Per cent Spurs Blossoming	Number Spurs with Fruit June	Number Spurs with Fruit Aug. 26	Number of Fruits Aug. 26	Per cent Blossoming Spurs with Fruit Aug. 26
Orchard No. 1	1	Bagged	Delicious	2¾	83	69	39	34	43	59.6
Tree 1	2	Bagged	Cortland	2½	71	85	44	28	30	46.7
	3	Bagged	Fameuse	2¾	70	90	39	27	34	42.9
	4	Bagged	Tolman	3	90	90	80	60	65	74.1
	5	Bagged	McIntosh	3¼	No count	No count	2	2	2	
	6	None	Unknown	3	98	77	33	14	15	18.7
Tree 2	7	Bagged	Delicious	2¼	51	73	33	25	30	67.6
	8	Bagged	Cortland	2¼	66	73	36	19	21	39.6
	9	Bagged	Fameuse	2¾	84	87	46	39	42	53.4
	10	Bagged	Tolman	2¾	100	86	56	40	48	46.5
	11	None	Unknown	2¼	94	93	33	14	14	16.1
Tree 3	12	Bagged	Delicious	2¼	86	79	41	28	32	41.2
	13	Bagged	Fameuse	2½	75	81	47	35	48	57.4
	14	Bagged	McIntosh	2½	63	92	22	9	9	15.5
	15	None	Unknown	3	74	86	15	12	12	18.8
Tree 4	16	Bagged	Delicious	2¾	85	82	50	34	42	48.6
	17	Bagged	Cortland	2¾	81	85	39	22	23	31.9
	18	Bagged	Fameuse	2¾	91	86	44	33	40	42.3
	19	Bagged	Tolman	3¾	91	73	45	36	42	54.5
	20	Bagged	None	2¾	83	80	10	3	3	4.5
	21	None	Unknown	3	73	90	12	7	7	10.6
Tree 5	22	Bagged	Delicious	2¾	86	71	41	25	28	41.0
	23	Bagged	Fameuse	3¼	115	87	60	34	37	34.0
	24	None	Unknown	3½	82	85	32	14	17	20.0
Tree 6	25	Bagged	Delicious	3	109	91	72	45	46	45.5
	26	Bagged	Fameuse	3¼	87	80	59	44	48	62.9
	27	None	Unknown	3¼	73	77	15	7	7	12.5

Tree 7	28	Bagged	Delicious	3	76	87	45	36	48	54.5
	29	Bagged	Fameuse	2½	60	75	31	30	45	66.7
	30	None	Unknown	3¼	94	78	27	24	24	32.9
Tree 8	31	Bagged	Delicious	2½	58	95	36	23	25	41.8
	32	Bagged	Fameuse	2	57	89	40	19	23	37.3
	33	None	Unknown	3	86	79	9	11	12	16.2
Tree 9	34	Bagged	Delicious	3	81	80	38	31	41	47.7
	35	Bagged	Cortland	3¼	105	85	68	51	57	57.3
	36	Bagged	Oldenburg	2¾	91	85	44	25	30	32.5
	37	Bagged	Wealthy	3	81	84	48	29	34	42.6
	38	Bagged	Earl. McI.	3¼	127	87	48	43	45	39.1
	39	Bagged	Milton	3	105	83	48	27	32	31.0
	40	None	Unknown	3½	88	88	17	15	16	19.5
Tree 10	41	Bagged	Delicious	3	79	80	37	40	48	63.5
	42	Bagged	Fameuse	3½	137	64	49	42	48	47.7
	43	Bagged	Fameuse	3	104	87	53	44	48	48.9
	44	Bagged	McIntosh	2¾	76	76	9	1	1	1.7
	45	None	Unknown	3¼	95	75	24	6	6	8.5
Orchard No. 2	46	Bagged	Delicious	2¾	94	77	47	43	50	59.7
	47	Bagged	Cortland	2½	92	66	44	28	29	45.9
Tree 11	48	Bagged	Tolman	2½	83	60	27	31	34	62.0
	49	Bagged	McIntosh	2¾	112	77	9	2	2	2.3
Tree 12	50	Bagged	Delicious	3	73	49	25	16	20	44.4
	51	Bagged	R. I. Gr.	2½	94	48	13	13	18	28.9
Orchard No. 3	52	Bagged	Delicious	3¼	163	47	32	27	29	35.1
	53	Bagged	Macoun	2½	86	66	22	20	22	35.1
Tree 13	54	Bagged	Lobo	3¼	163	74	36	33	34	27.5
	55	Bagged	McIntosh	3¼	144	81	2	3	3	2.6
	56	None	Unknown		115	64		13	13	17.6

ness of the different pollens, especially in view of the uniformly heavy bloom on the unit branches. Since Delicious was known to be one of the most effective pollenizers for McIntosh (1, 2), it was used as a criterion to judge the relative pollen value of the other varieties.

A summary of the results obtained on bagged branches is given in Table II. As would be expected, the pollen of all varieties applied to McIntosh blossoms produced a much heavier set than resulted from self-pollination of McIntosh, a variety known to be almost wholly self-sterile. Inasmuch as 20 to 25 fruits on a unit branch, or a set of about 25 to 30 per cent of the blossoming spurs when bloom is heavy, are sufficient for a good crop on trees of this age, it is seen that all varieties tried were effective pollenizers for McIntosh as far as the potency of the pollen is concerned. Even though a pollen was used only once, the good results obtained under the conditions of the experiment are strong evidence that the varieties would be satisfactory pollenizers under orchard conditions. Milton, Macoun, and Early McIntosh pollen have also given good results on McIntosh in western New York. Negative results would, of course, have little significance with so few trees.

TABLE II—SUMMARY OF RESULTS OBTAINED WITH DIFFERENT POLLENS ON BAGGED MCINTOSH BRANCHES, PERU, N. Y., SPRING, 1929.

Pollen Variety	Number Orchards	Number Trees	Number Unit Branches	Av. Number Spurs With Fruit Aug. 26	Av. Per cent Blos. Spurs With Fruit Aug. 28
Delicious	3	13	13	31.3	50.1
Fameuse	2	10	11	34.4	49.3
Cortland	2	5	5	29.6	44.3
Tolman	2	4	4	41.7	59.3
Wealthy	1	1	1	29.0	42.6
Oldenburg	1	1	1	25.0	32.5
Early McIntosh	1	1	1	43.0	39.1
Milton	1	1	1	27.0	31.0
Macoun	1	1	1	20.0	35.1
Lobo	1	1	1	33.0	27.5
McIntosh	3	5	5	5.4	5.5

In determining whether or not lack of cross-pollination was limiting the set of fruit, pairs of comparable branches were chosen on selected trees in a number of orchards. In three instances, every tree or alternate trees in a row extending some distance across the block were used. Both branches of the pair were exposed to insect visits and one of each pair had good pollen applied to two or three blossoms of each flower cluster. The data given in Table III are of special interest. This row was in a block of 800, 23-year-old McIntosh trees on a 16-acre tract.* Although in good vigor and blossoming heavily each year, the orchard had never had a satisfactory crop. Several colonies of bees and pollen bouquets were located near tree four. Tree 17 was at the edge of the orchard with pollenizers

*The blocks referred to are parts of a 90 acre 23-year old orchard in which about 95 per cent of the trees are McIntosh.

scattered over the adjoining field. A mixture of Delicious and Hubbardston pollen was used on this row. From the data it is evident that even in the exceptionally favorable season of 1929, with six days ideal for insect flight, the limiting factor in securing a crop was the lack of cross-pollination. It is also evident that the effect of the bouquets was very local, not extending for more than one or two trees.

Slightly less striking results were obtained on a second row in another part of the Northern Orchard Company's plantings. This second row is near the center of a nearly square block of 350 McIntosh trees covering seven acres*. Adjacent to this block on the east are trees of the varieties Fameuse, Tolman, and Delicious and the test trees were nearer pollenizers than in the first case, referred to in Table III. Different pollens were used on the different trees so the results on the hand-pollinated branches were more variable than those in Table III. In this second row the hand-pollinated branch had the larger set on 9 out of 11 trees. The two exceptions were with Oldenburg pollen, which gave a heavy initial set, followed by a very heavy June drop which reduced the percentage on the hand-pollinated limbs to below that on those open-pollinated.

Also, the set on the open-pollinated unit branches was larger on this row than on comparable unit branches reported in Table III, the actual percentage set being 25.6 as compared with 20; the number of blossoming spurs holding fruit August 26 was 19.4 on this row as compared with 9, for the branches listed in Table III.

In the Champlain Valley Orchard Company's planting a similar experiment was carried out on 14 McIntosh trees of a row extending into a large block. In this orchard there were Fameuse trees on one side of the row chosen about three rows distant, and some scattered Rhode Island Greening trees nearer by. A number of colonies of bees were located at one end of this orchard near the row used. On 10 out of 13 trees there was a larger set on the hand-pollinated limbs than on those open-pollinated. On this row, the average number of blossoming spurs holding fruits on the hand-pollinated limbs August 28 was 27, and on the open-pollinated 19. The percentage of blossoming spurs holding fruit on August 28 was 74 on the former, and 56 on the latter. It is thus seen that although the hand-pollinated branches set heavier in most cases, yet the set with open-pollination was sufficient for a good crop. It is of interest to note that in this row also two of the instances in which the set on the hand-pollinated branches was less than those open-pollinated were treated with Oldenburg pollen which caused a heavy early set followed by a heavy June drop.

In two different solid blocks of McIntosh at Chazy, N. Y., significant increases in set resulted from hand-pollination. On eleven hand-pollinated unit branches, in all but one instance the set was greater than upon the open-pollinated check branch. In these blocks the average number of fruits on the hand-pollinated branches on August 30 was 25.3 and on the open-pollinated 14.5. The percentage of blossoming spurs setting fruit was 66 on the former, and 38 on the latter.

TABLE III—RESULTS OF HAND-POLLINATION COMPARED WITH OPEN POLLINATION ON UNPROTECTED BLOSSOMS IN A SOLID BLOCK OF McINTOSH IN A SEASON VERY FAVORABLE FOR INSECT FLIGHT, PERU, N. Y., SPRING, 1921.

Tree Number	Branch Number	Treat-ment	Circum. of Branch (inches)	Total Number of Spurs	Per cent Spurs Blos.	Number Spurs With Fruit Aug. 26	Number Fruits Aug. 26	Per cent Blos. Spurs With Fruit Aug. 26
4	101 102	Pol.* check	3 3	79 63	95 92	39 17	45 19	52.0 29.3
5	103 104	Pol. check	2½ 2¼	56 59	80 85	23 14	30 14	51.1 28.0
6	105 106	Pol. check	3 3	77 79	81 73	31 8	32 8	50.0 13.8
7	107 108	Pol. check	3 3	74 52	86 63	34 9	36 10	53.1 27.3
8	109 110	Pol. check	2¼ 2¾	72 83	85 84	33 7	37 7	54.1 10.0
9	111 112	Pol. check	2¾ 2¼	76 61	82 66	24 6	26 7	38.7 15.0
11	115 116	Pol. check	3 3	62 48	61 83	17 4	23 4	44.7 10.0
12	117 118	Pol. check	3 2¼	57 71	91 76	19 8	21 8	36.5 14.8
13	119 120	Pol. check	2¾ 2½	48 56	85 79	14 6	14 6	34.1 13.6
14	121 122	Pol. check	2¾ 3	76 65	70 48	26 7	25 7	49.1 22.6
15	123 124	Pol. check	2½ 2½	72 54	89 81	36 9	43 9	56.3 20.5
16	125 126	Pol. check	2¾ 2½	92 47	75 81	28 7	28 8	40.6 18.4
17	127 128	Pol. check	3 3	65 74	82 78	24 19	26 23	45.3 32.8

*A mixture of Hubbardston and Delicious pollen was applied to the odd numbered limbs on each tree.

Different results were obtained in the Forrence Orchard. This is a solid block about 15 trees square of 6-year-old McIntosh, but with large adjacent mixed plantings on the north and east. This particular year, hand-pollination resulted in no apparent gain, even in the center of the block. In the Sullivan McIntosh block, the three year yield record of the 3rd, 4th, and 5th rows from a mixed planting show no correlation with distance from pollenizers, the 1929 yields per row being 88, 86, and 85 bushels, respectively. Other orchards showed a similar condition. In this particular year, therefore, with its extremely favorable weather for insect flight at blooming

time, set was limited by lack of cross-pollination only in the larger solid blocks of McIntosh.

In this connection it may be pointed out that the distance over which pollenizers are effective depends upon the number of pollen sources and the amount of pollen available. Thus, a single row or a broken row of pollenizers will not be effective for so great a distance as a solid block. For example, in the Witherell orchard at Shoreham, Vt., a block of 1,000 McIntosh trees, eight rows wide, adjoining a block of 600 Delicious, set a uniformly heavy crop throughout, so far as the eye could detect. In the Atwood orchard at Plattsburg, N. Y., individual yield records on about 90 McIntosh trees in a square block showed the second and the fourth highest yielding trees to be nine trees removed from pollenizer trees. As has been brought out earlier, this was not the case in orchards where the pollenizers were few.

In the Northern Orchard Company's planting at Peru, a 15-year-old McIntosh tree was caged with a hive of bees and bouquets of a number of good pollen varieties. During the five warm days of the blossoming season the bees were excessively active working the blossoms, so active in fact, that it was impossible to get into the cage to pollinate bagged check branches. After petal fall, the set on this tree was observed to be very heavy. On one unit branch, of the 46 spurs that bloomed, 45 had fruit in June, each spur holding about three fruits. By September, the number of spurs carrying fruit had dropped from 45 to 12, and the number of fruits from 133 to 12. Among 60 cross-pollinated branches at the Northern Orchard Company, this branch had the highest percentage of blossoming spurs with fruits in June and second lowest in September. Evidently, the excessive amount of pollination that occurred within the cage resulted in a very heavy set early, but so acute was the competition among the fruits that over 90 per cent of them was shed. The behavior of this limb was typical of the whole tree. The decreased set due to the pollination of many flowers on the same spur as compared with the set on spurs where only two flowers were pollinated has been shown by Howlett (3). A similar instance was also found in western New York where with pairs of unit branches on seven Baldwin trees, the Delicious-pollinated branches set less in every case, the average percentage of blossoming spurs holding fruit after the June drop being 38.3 on the open-pollinated and 23.1 on the hand-pollinated branches. The average number of fruits per unit branch on the former was 19.4 and 12.4 on the latter.

Seed counts were made on several lots of McIntosh apples at the Northern Orchard Company's planting. Two lots of six apples each, taken from the center of a large solid block of McIntosh about 400 feet removed from the nearest other variety, each showed 2.2 seeds per apple. In the same block, but about 100 feet from a pollenizer, a lot of 19 apples showed an average seed count of 3.4 per apple. A lot of 47 apples from a McIntosh tree adjacent to a Fameuse tree, and also near a Tolman, gave a seed count of 4.6 per apple. Four small lots of hand-pollinated fruits showed 4.2, 5.0, 5.2, and 8.5 seeds per apple, respectively. The results obtained in the Weaver orchard

were similar. A lot of 24 apples from the center of a solid McIntosh block of about 300 trees showed a seed count of 3.7, whereas in a nearby block containing some Fameuse, Spy, and Delicious trees among McIntosh, the seed count was 4.9. Since the number of seeds is an index to the extent to which cross-pollination has taken place, these results are supplementary evidence as to the lack of cross-pollination in large blocks even in such a favorable season as 1929.

TABLE IV—POLLINATION RESULTS OBTAINED ON BAGGED FAMEUSE BRANCHES —SPRING, 1929

Branch No.	Pollen Variety	Circum. of Branch (inches)	Total No. of Spurs	Per cent. Spurs Blos.	No. Spurs With Fruit Aug. 28	No. of Fruits Aug. 28	Per cent. Blos. Spurs with Fruits Aug. 28
33A	*Mixed	1¾	29	86	14	16	56.0
33B	"	2	40	95	14	19	36.8
34	Fameuse	3	85	55	3	3	6.4
35	"	2¾	95	76	3	3	4.2
36	"	2½	75	80	0	0	0

*A mixture of Hubbardston and Delicious pollen.

From the results given in Table IV it is evident that Fameuse is in high degree self-sterile, at least where the branches are bagged. This was hardly to be expected in view of the common observation that this variety in comparatively large blocks sets a crop practically every year when it blooms even under conditions where McIntosh has failed to set. It is probable that Fameuse is in the same class of varieties as Wealthy and Jonathan which set with a minimum of pollination and hence usually set when they bloom under good orchard conditions, but fail to do so if bagged and self-pollinated. The self-sterility of Fameuse has been observed by other workers (4).

DISCUSSION

These tests of different pollens applied by hand to the receptive stigma indicate that all varieties tried will give a satisfactory set. Other important considerations, such as date of blooming, must, however, be considered. Thus in 1929, when 50 per cent of the McIntosh blossoms were open, only about five per cent of the Tolman blossoms were open. Since the anthers may not dehisce until a day or two after the blossoms open, Tolman is not a satisfactory pollenizer to use alone. From these data, Fameuse appears to be outstandingly desirable for the Champlain Valley region. It produces good pollen, is hardy, has fair market demand, and in most seasons it blooms about a day earlier than McIntosh so that the pollen is ready for distribution as soon as the McIntosh blossoms open. Since it is inclined to be a biennial bearer, it would probably be wise to supplement it with some other variety such as Oldenburg or Wealthy. Delicious, besides blooming late, does not thrive in most orchards of the Champlain Valley. Cortland and the other McIntosh seedlings are not yet proven varieties for the region, but are worthy of some

consideration. Macoun is known to be a late blooming variety and several of the others may be. For maximum provision for cross-pollination of McIntosh, early blooming varieties such as Oldenburg and Fameuse should be combined with later bloomers like Wealthy and Cortland.

The results obtained in testing out whether or not cross-pollination was limiting the set give the situation in a year of exceptionally favorable weather conditions. That there should be a difference due to cross-pollination even in the largest solid McIntosh blocks in such a year is significant. From observations in 1926 and 1928, it is practically certain that the effects would be more striking in most years, and that the distances over which pollenizers would be effective would be much less. There is, thus, every indication that growers in this region should give serious consideration to provision for cross-pollination.

Literature Cited

1. MacDaniels, L. H. Pollination studies in New York State. Proc. Amer. Soc. Hort. Sci. (1928) 25: 12. 1929.
2. Wentworth, S. W., Furr, J. R., and Mecartney, J. L. The spur-unit method of determining the comparative effectiveness of different varieties of apple pollen. Proc. Amer. Soc. Hort. Sci. (1927) 24: 85. 1928.
3. Howlett, Freeman S. Fruit setting in the Delicious apple. Proc. Amer. Soc. Hort. Sci. (1928) 25: 143. 1929.
4. Gorham, Alexander C. The pollination of the McIntosh and Fameuse apples. Thesis (unpublished) Cornell University, 1919.

Effects of Treatments on Dormant Potato Tubers Measured by Respiration Rates, Permeability to Gases, Interior Gas Analyses, and Length of Rest Period

By Ora Smith, *Stillwater, Okla.*

The material contained in this paper has been published in Hilgardia, of the California Agricultural Experiment Station.

Some Factors Influencing the Growth of Apple Seedlings

By CHARLES F. SWINGLE,[1] *United States Department of Agriculture, Washington, D. C.*

IT MAY not be assumed that the behavior of a group of apple seedlings offers direct evidence as to how such seedlings would have behaved as grafted trees. One may easily draw analogies from the behavior exhibited by unworked trees, but such deductions should be made only with caution and must take into consideration the reciprocal influence of stock and scion. The growth response exhibited by seedling trees however, is not entirely without significance in the consideration of stocks. With this in mind, there were assembled in the spring of 1921 at the U. S. Horticultural Field Station, Glenn Dale, Maryland, several lots of one-year commercial apple seedlings, including trees grown in France, some grown in the United States from French-imported seed, and others from American seeds. All were Grade 1, *i. e.* calipering $\frac{3}{16}$ inch or larger when received.

These trees grew undisturbed during 1921 and 1922. In the spring of 1923 all were dug and approximately half discarded, only the largest and the smallest of each lot being saved. This was the only conscious selection made at any time during the course of the experiment. All the trees retained were planted in a block 18 inches apart in rows 4 feet apart. Every alternate tree of each lot was transplanted in 1925 and half the remainder transplanted in 1926, so that during the last three seasons the trees stood 4 x 6 feet. All trees received ordinary light root-pruning when transplanted; part of the trees were topbudded to Delicious in 1924 and the following winter these received the severe heading back incident upon such topworking. Beyond this, pruning in all cases was limited to keeping off suckers, which means that the trees not budded were really unpruned, while those which were budded were headed back severely.

No actual measurements were taken until 1924, one year after the separation into the groups of "small" and "large" trees. The variation between individual trees in the same lot was then found to be far above the group differences shown between different lots of seedlings. Consequently in Table I, all trees are grouped together so far as source is concerned and all considered as a mixed group of miscellaneous seedlings.

From the first two columns of Table I (trees not budded and not transplanted after 1923) it is evident that the size at planting time (1923, after three years growth) had a very important influence upon subsequent growth, the average diameter of the "small" group still being much below that of the "large" group in 1929. That is, though all seedlings had made Grade 1 by the end of the first season's growth, many of these for some reason or another—whether genetical

[1]This paper presents in final form the results of the experiment preliminarily reported before this society in 1926. This experiment was started by G. E. Yerkes who has also helped in the subsequent operations and in the preparation of the results in this form.

TABLE I—EFFECT OF BUDDING AND TRANSPLANTING ON GROWTH OF APPLE SEEDLINGS.

One-year trees purchased 1921, grown 1921 and 1922. Medium size trees discarded, small and large trees transplanted spring 1923. Subsequent treatment as indicated. (Measurements in sixteenth of inch, two inches above the ground.)

	Check Trees		Budded 1924		Transplanted 1925		Transplanted 1926		Budded 1924 Transplanted 1926	
Number	Small 25	Large 20	Small 27	Large 21	Small 103	Large 95	Small 16	Large 18	Small 24	Large 20
1924 (April)										
Av. diameter	8.6±.280	14.7±.276	9.0±.213	14.6±.298	8.4±.136	14.3±.164	8.2±.276	14.3±.518	8.2±.206	14.5±.510
Range	5–13	9–21	6–13	12–19	5–13	8–21	5–12	9–19	5–11	9–20
Stand. dev	2.07	1.85	1.64	2.03	2.06	2.36	1.64	3.30	1.50	3.40
C. V	24.06	13.21	18.22	13.91	24.43	16.50	20.00	22.80	18.29	23.31
1926 (Oct.)										
Av. diameter	23.0±1.08	33.3±.995	18.3±.635	25.8±.883	19.7±.314	26.2±.37	16.3±.656	25.9±1.08	12.3±.468	20.3±.497
Range	8–40	21–48	11–30	19–32	9–32	15–40	9–23	18–38	6–17	15–29
Stand. dev	8.02	6.60	4.90	6.00	4.70	5.30	3.90	6.80	3.40	3.30
C. V	34.86	19.79	26.77	23.27	24.01	20.40	23.86	26.33	27.64	16.26
1929 (Feb.)										
Av. diameter	32.7±1.66	45.3±1.56	24.3±.993	33.3±.830	29.7±.569	36.5±.627	21.1±.649	33.7±1.52	17.5±.500	26.8±.909
Range	11–52	26–68	14–46	22–45	11–50	18–60	13–28	22–46	8–23	21–33
Stand. dev	12.32	10.35	7.65	5.67	8.57	9.10	3.85	9.60	3.60	6.00
C. V	37.70	22.84	31.48	17.03	28.85	24.85	18.25	28.45	20.68	22.45

or environmental—fell behind during the next two years' growth, and once developed, these differences did not tend to disappear.

Hence it is evident that the size at the end of three years' growth offered a much better criterion for predicting subsequent growth than did the size at the end of the first season's growth. Nevertheless, both the coefficient of variation (C. V.) and the range, indicate that many individual trees of the "small" group were larger than the average of the "large" group.

Columns 3 and 4 show similar differences between the "large" and the "small" groups with similar ranges and coefficients of variation. However, it is apparent that budding exerted a very marked inhibitory effect on the growth of seedlings of all sizes. This slowing down of growth the first two seasons after budding is in accord with accepted horticultural ideas but it is surprising that this differential between budded and non-budded trees did not tend to disappear during 1927 and 1928. Is this because the non-budded trees, having "gotten the jump" on the others so far as plant-food and light was concerned, kept their lead, or is it because of some internal effect of the budding with its accompanying heading back?

Columns 7 and 8 show that transplanting in 1926 (a dry spring) was still more inhibitory in effect than transplanting in 1925 (an ordinary spring).

As would be expected, combining these two inhibitory factors (budding, and transplanting) should bring about a still more pronounced retardation of growth. This is shown in the last two columns of Table I. As in all other cases, the figures for 1929 here show that the trees behind in 1926 were not tending to catch up.

Summing up the results shown in Table I, it is evident that however brought about, the trees once checked in growth tended to remain permanently smaller than the ones never retarded. Also, in every group of trees, whatever the treatment, tremendous size ranges occurred.

Spray Oil Penetration Into Apple Leaves, Limbs, and Fruit

By P. A. Young, *Bozeman, Mont.*

The material contained in this paper will probably be published in the Journal of Plant Physiology.

Notes on Root Stocks for *Prunus Tomentosa*

By Charles F. Swingle, *United States Department of Agriculture, Washington, D. C.*

THE Chinese bush cherry, *Prunus tomentosa* Thunb., seems to be increasing in popularity both for use as an ornamental plant and as a dwarf fruit tree.[1] Although seedlings of this cherry are relatively easy to obtain, great variability exists among them as with seedlings of most fruit trees, hence some means of vegetative propagation must be employed to perpetuate the desirable varieties that are being selected. Both hardwood and softwood methods of cutting propagation, as well as layering, have been used to propagate this plant, but even though several workers have reported fair success in the use of these methods, budding and grafting will probably continue to be used for some time with *P. tomentosa.* The root-stock problem therefore demands attention.

Seedlings of tomentosa itself are occasionally used as stocks, but *P. davidiana* Franch (*Amygdalus davidiana*) seems to be the stock most in use for *P. tomentosa* in the United States and in the Orient. Although generally satisfactory as a stock, the difficulty of obtaining seed of *P. davidiana,* together with the question of its hardiness in certain regions where *P. tomentosa* may prove adaptable, make it highly desirable that as many different kinds of root stocks as possible be tried and the results reported.

Apparently *P. nigra* Aiton, and *P. besseyi* Bailey, are the only other forms of Prunus whose use as root stocks for *P. tomentosa* have thus far been reported. Several other stocks have perhaps been used by other workers, and it is emphasized that all results of the use of such forms should be recorded, whatever the outcome of the tests. Because our knowledge about root stocks is so slight, the results of even unsuccessful trials with *P. tomentosa* (as well as with all other new combinations of root and scion) should be recorded.

During the summer of 1924, a few plants each of all available types of Prunus growing at the U. S. Horticultural Field Station, Glenn Dale, Md., were budded to *P. tomentosa.* The stocks used included plants grown from root cuttings, layers and seeds, and were from one to ten years of age. Of this trial, no unions even temporarily satisfactory were obtained with any plants of the following: *P. avium* L. (Mazzard); *P. cerasus* L. (Montmorency); *P. mahaleb* L.; *P. serrulata* Lindl.; *P. serrulata sachalinensis* Makino (Sargent Cherry); *P. serotina* Ehrh.; *P. pumila* L. (Sand Cherry); *P. besseyi* Bailey (Western Sand Cherry).

These negative results of course indicate little regarding congeniality; in fact, in the case of the last two mentioned forms (the sand cherries) the results were not due to complete lack of congeniality, for of a previously budded lot of *P. pumila,* one plant made a satisfactory union and is now in fairly good condition at the Glenn Dale

[1]For an account of the introduction of this plant, its uses as an ornamental, as a substitute for present cultivated sweet and sour cherries, methods of propagation, etc., see the article by G. M. Darrow in the Journal of Heredity for April, 1924.

Experiment Station. Darrow reported that *P. besseyi* has been successfully worked to *P. tomentosa*.

Neither *P. besseyi* nor *P. pumila*, however, seems to be satisfactory for use as a stock, whatever the compatability. Both forms lose their leaves early in the season, thus making for difficulty in budding and both seem to be very susceptible to the peach borer (*Aegeria exitosa* Say). Added to these faults both sand cherries sucker badly.

P. insititia L. (St. Julien plum), *P. cerasifera* Ehrh. (Myrobalan), and *P. communis* Fritsch. (Almond) made apparently satisfactory unions with *P. tomentosa* and the resulting plants showed good growth at the end of the first year (1925). The plants on these three stocks, however, were transplanted during the excessively dry spring of 1926 and all were lost.

Plants of *P. tomentosa* budded in 1924 on the following stocks are now fruiting at the Glenn Dale Experiment Station:

P. persica S. & Z. (peach, Peento type). One limb only was budded so that the top of the tree is about three-fourths peach and one-fourth cherry. The tomentosa branch has grown very vigorously and has nearly kept up with the remainder of the top. The union seems to be entirely satisfactory.

P. hortulana Bailey (Hortulana Plum). The entire plant was top-worked 40 cm. above ground. Only normal overgrowth is shown at the union, and the large size of this plant indicates that the union is physiologically sound.

P. munsoniana W. & H. The bud was inserted about 15 cm. above the ground. After the first three years this had grown into a plant almost as large as the one on the Hortulana root. The union, however, showed considerable overgrowth and recently the scion has almost completely separated from the stock.

P. mexicana Wats. (Big-Tree Plum) 2 plants. Both were top-worked about 25 cm. above the ground. The union in each case seems to be satisfactory and the plants are apparently healthy; however, one of the plants has remained very small, and after four years' growth is straggly and less than a meter high. The other one has made moderate growth and is almost 2 meters high, with a good spread. In view of the extreme vigor generally shown by trees of *P. mexicana*, these results are somewhat surprising.

P. reverchoni Sarg. (Hog Plum). This plant, while showing a good union, is only slightly larger than the smaller one of those budded on *P. mexicana*.

P. besseyi x *triflora* (Sapa Plum) 2 plants. These plants were budded on the new shoots from mound-layered plants so that each of these might be divided into three or four separate ones. Little difference in size is shown between these plants on Sapa and the one on *P. pumila*, though of the two, Sapa seems preferable as a stock, for it apparently is much less susceptible to attacks of the peach borer and less addicted to the suckering habit than is the sand cherry itself. Likewise one would confidently expect greater uniformity from the use of vegetatively propagated stocks than from miscellaneous seedlings.

P. besseyi x *simoni* (Tokeya Plum) 4 plants. This plum, which is quite like Sapa, behaved much like it when used as a stock for *P. tomentosa*.

It is fully realized that the notes here presented are necessarily of a very superficial and preliminary nature, and are not to be considered in any other light. Particularly should it be emphasized that within a single lot of seedlings of the same species, a tremendous range of variation as regards size, compatibility, etc., is frequently found and that ultimately, stocks for *P. tomentosa*, along with those for most fruit trees, will undoubtedly be put upon a clonal basis. The apparent usefulness, however, of any information that bears upon the problems of root stocks has led the writer to present the available information on the behavior of these *P. tomentosa* stocks.

Investigations on the Propagation of Apples from Root Cuttings*

By W. H. UPSHALL, *Vineland Station, Ontario, Canada*

IT has been pointed out in a previous paper (4) that root pieces taken from own-rooted apple trees and older seedling trees give very poor results in propagation, whereas root pieces from one-year apple seedlings give excellent results. Furthermore, it has been shown that the former give an equally poor stand when used as stocks for bench grafts.

One-year, Kansas-grown French Crab has always given a good stand and good growth from root cuttings. Root piece grafts were made using variety roots and one-year French Crab roots, both as stock and as scion, each about two inches long. The grafts were set in a greenhouse, in a sand-peat moss mixture. Results are presented in Table I.

TABLE I—ROOT PIECE GRAFTS IN GREENHOUSE

Year	Scion	Stock	Total grafts	Variety pieces Number	Percentage Rooted	Remarks
1927	8 varieties	1 yr. Fr. Crab	48	0	0	Much rot
	1 yr. Fr. Crab	8 varieties	48	9	19	" "
1928	1 yr. Fr. Crab	8 varieties	54	30	55	Healthy

It is unfortunate that disease more or less spoiled the results of 1927. The table refers to grafts of a root on a root and not the usual stem on a root. One-year French Crab as a "nurse" root (stock) did not induce the scion, a variety root piece, to produce new roots. On the other hand, when French Crab was used as a "nurse" scion 19 per cent and 55 per cent of the variety root pieces formed new roots. The corresponding figures for comparable ungrafted variety root pieces were 3.6 per cent and 6.0 per cent. Halma (1) obtained similar results with citrus roots from old trees using a leafy citrus shoot as a "nurse" top. Apparently the "nurse" top contributed something to the variety root piece which induced it to root. This finding, together with the fact that some of the variety root pieces form new roots, seemed to suggest that the difficulty of propagation was due not to a fault of internal structure but to inadequate nutrition. It seems much more likely that the "nurse" top changed the nutrition of the stock piece than that it changed the structure. It has not yet been determined what percentage of the variety root pieces will form new tops when the "nurse" piece is removed, but at least some of them will do so. In any case this procedure would prove too time-consuming to be of practical application.

It would be interesting to know whether, using a one-year French Crab seedling root piece as a "nurse" top, one would secure new roots large enough for propagation purposes in one year from the variety

*Part of a thesis submitted to the University of Maryland in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

stock piece. It is possible that such one-year-old variety root pieces would give a different propagation response to variety roots obtained from two- or three-year-old own-rooted plants. Ordinarily, own-rooted plants are two or three years old before the roots are large enough to use for propagation purposes.

Another field that promises some results on stimulation of root pieces which root with difficulty is that of water culture. Much better growth of tops was obtained by growing root pieces for two or three weeks in about an inch of tap water, changed daily, and then transferring to a shaded propagation bed, than was secured from cuttings placed directly in the solid medium. However, the production of new roots was not always increased by this treatment. Chloride, oxidizing, and sugar solutions as water cultures gave no consistently better results than water alone. Root pieces often grew a new top and roots and remained healthy in tap water for two or three months, at the end of which time they came to a standstill and finally died.

As early as one week after planting, gum appears in the vessels of apple root pieces and becomes shortly thereafter an effective barrier to the vascular movement of water. The gum appears most rapidly and in the greatest abundance in the root pieces which are most difficult to propagate. It does not occur in normal roots at the time they are cut from the tree.

Variety roots and roots from older seedlings are usually slightly lower in carbohydrate content than are the French Crab roots but the difference is not marked. Starch and hemicellulose are the main reserve foods. Neither of these differs significantly in quantity in these two classes of roots Based on green weight, the starch and hemicellulose content each averaged about 7 per cent in January. In April the starch content of freshly dug roots was still about 7 per cent but the hemicellulose content was only 4 per cent. This condition together with the fact that hemicelluloses decrease in the root pieces during propagation lends support to Murneek's conclusions (3) that hemicelluloses are important reserve foods in the apple. No analyses for nitrogen have been made but the activity of catalase is much less in the variety roots than in the one year French Crab roots indicating a difference in nitrogen content in the bark (2). The activity of amylase is also less in the variety roots but apparently this is not a factor since chemical analyses show that in the propagation bed there is little difference in the rate of reduction in reserve materials. No consistent differences in rate of respiration were found between the one-year French Crab roots and the variety and older seedling roots.

Literature Cited

1. Halma, F. F. Promising method for propagating the rootstock of old citrus trees. Calif. Citrog. XII No. 5, 152. 1927.
2. Heinicke, A. J. Seasonal variation in the nutrient condition of apple trees as indicated by catalase activity. Proc. Amer. Soc. Hort. Sci., 234–239. 1928.
3. Murneek, A. E. Hemicellulose as a storage carbohydrate in woody plants, with special reference to the apple. Pl. Phys. 4:2, 251–264. 1929.
4. Upshall W. H. and Gardner, F. E. Responses of variety and seedling roots to attempts at propagation. Proc. Amer. Soc. Hort. Sci., 172–174. 1928.

American Mazzard Cherry Seedlings as Root Stocks for Cultivated Cherries

By J. A. McClintock, *University of Tennessee, Knoxville, Tenn.*

THAT many more cherries are budded on Mahaleb than on Mazzard stocks at the present time in the United States is common knowledge. In "The Cherries of New York," Hedrick says that the Mahaleb began to be used as a stock in America about 1850, and by 1915, 95 per cent of the cherries in this country were budded on Mahaleb. The extent to which Mahaleb stocks are used in this country is indicated by the fact that more than 6,000,000 were imported from Europe, and more than 1,250,000 were grown in the United States in 1928. The delay of the quarantine on Mahaleb stocks until June 30, 1931, is evidence that American nurserymen expect to continue using these stocks. By that time it is expected America will be able to produce more than 7,000,000 Mahaleb seedlings annually.

Nurserymen in the eastern United States who have tried American-grown Mahaleb stocks have not had as good results with them as with imported Mahaleb stocks. When nurserymen are changing from European to American grown stocks it would seem to be the opportune time for horticulturists to exert their influence to obtain better cherry stocks.

In 1927, Howe, in New York State Station Bulletin No. 544, presented evidence that 40 cultivated varieties of cherries are more vigorous and longer lived on Mazzard than on Mahaleb root stocks. In recent correspondence he says that data collected on this experiment since the publication of the above mentioned bulletin give additional substantiating evidence to the effect that cherries grow better on Mazzard than on Mahaleb root stocks. It is stated that commercial nurserymen near the Geneva Station have been impressed by these experiments, and are now producing cherry trees on Mazzard stocks. Aside from this local effect nurserymen appear to be little influenced by these root stock experiments, and will continue to use Mahaleb stocks unless horticulturists demand changes.

What the New York State Station proved by experiments, orchardists are learning all over the country, namely, that cherry trees on Mahaleb root stocks are weak in growth and short lived. Complaints to this effect are coming to nurserymen to the extent that some of the more progressive are asking for better stocks than Mahaleb.

Most of the nurserymen now using Mahaleb stocks have at some time tried imported French Mazzard stocks. The poor results obtained with these stocks in many cases, influenced them more than ever to use Mahaleb. This is because in the nursery row the Mahaleb is more vigorous, holds its leaves better, and remains in good condition to bud over a longer period of time. In many cases a better set of buds is obtained on the Mahaleb, and the result-

ing trees on Mahaleb roots grow larger in the nursery row. At this stage the nurserymen and the trees part company at a better profit to the nurseryman than if they had been grown on Mazzard roots. While the purchaser appears to be getting the most for his money, subsequent growth is disappointing. One of our commercial cherry growers in Tennessee who had profited in the early years of his orchard, and had been very optimistic about cherry growing is now pulling up his cherry trees and replanting to apples. This particular orchard was set in 1915 to Early Richmond, Montmorency, and Coe's Transparent on Mahaleb roots, and they began dying at 8 to 10 years of age.

In connection with studies of root stocks, French Mazzard and Mahaleb stocks were imported and set in test blocks in 1923. At that time and subsequently attempts were made to bud lined-out, imported Mazzard stocks during August, as is commonly done in commercial nurseries. In all cases the results have been in agreement with commercial nurserymen to the effect that French Mazzard stocks are not in as good condition to bud, and that a smaller percentage of buds form good unions. This is largely due to the fact that the French Mazzard stocks are more susceptible to the attacks of the cherry leafspot fungus, *Coccomyces hiemalis*. The heavy infection causes premature defoliation and the resulting slow growth renders these stocks difficult to bud. If nurserymen were dependent upon imported French Mazzard stocks they would have to practice more thorough spraying than most of them do at the present time to insure even a reasonable stand of buds.

Tests with imported French Mazzard pits are not as promising as those with imported stocks. This is because the pits reach the United States so late, and in such dry condition that germination is very poor. These objections might have been overcome by better methods of handling in Europe, and more prompt shipment to America.

In the test block the imported French Mazzard trees did not begin bearing until they were six years of age. Since then the yields have been light as compared with Mahaleb trees of the same age. From the tests thus far one would not be encouraged to set orchards of French Mazzard for seed purposes in the United States.

Another objection to the imported French Mazzard stocks, as the writer has observed them growing in the test blocks since setting in 1923, is their susceptibility to trunk cankers. On these, two fungi, *Schizophyllum commune* and *Stereum rameale*, were found fruiting. In some cases these cankers have resulted in the death of the trees. Experiments are being conducted to determine whether the associated fungi are the cause of the cankers, and whether the American Mazzard stocks are susceptible to infection.

The unpromising results obtained with French Mazzard stocks grown according to nursery practice, i.e., without spraying, induced the writer to look for something better in the way of sweet cherry stocks. A survey of available sources of material disclosed the fact that sweet cherries were growing wild throughout the eastern United States. These are known under the common name of Black Heart

cherries in the southeastern states, but are typical wild Mazzards. The wild trees are large and vigorous, and appear to be well adapted to varied soils. Many of these trees are more than a hundred years old and compare favorably in size with large forest oaks. Whatever their origin, those producing good crops at the present time are the survival of the fittest. They should prove good American sources of sweet cherry seed. In appearance these pits are similar to the French Mazzard pits and as nearly uniform. Those obtained from Virginia during the past five years average more than 2500 pits to the pound. These American Mazzard cherries probably vary considerably in their time of ripening in different sections, but those from which our pits have been obtained are harvested during the first half of July. These pits have a high percentage of viability, so it would appear that they fall in the class of late maturing varieties, which Tukey has shown give higher germination.

Difficulty has been experienced in holding these American Mazzard pits dormant when stratified in damp peat moss and stored at 40°F. On January 11 of this year many of the pits in the stratification boxes were germinating. It was then too early to plant these germinating seed in the field. Since there was no storage room below 40°F. into which the stratification boxes could be moved, the sprouted seed were transplanted, setting them in pots of soil in the greenhouse. These seedlings continued to grow rapidly and were much crowded in the pots before suitable weather for transplanting to the field had arrived. Some pots were transferred to glass covered coldframes to retard growth, but even these grew rather large for transplanting before weather would permit their transfer to the nursery rows. If greenhouse space had been adequate the seedlings could have been set less thickly in a larger number of pots, and would have remained in good condition to transplant to the field. As it was, the roots became considerably matted in the pots, and the seedlings had to be planted in clumps when transferred from the pots to the nursery rows. Under these conditions they grew slowly and never reached the size of seedlings from seed planted directly in nursery rows.

This year the length of the stratification period is being reduced and also other methods of holding the seed until planting time are being tested. A test is also being made of planting seed directly in the nursery row in the fall, as is done with peach pits.

American Mazzard cherry pits obtained in 1925, held at room temperature for several months in dry storage, and planted in comparison with imported French Mazzard, gave poor stands of seedlings. Thus the ability to get seed as soon as harvested is one of the strongest factors in favor of American Mazzard seed.

American Mazzard seedlings have been compared with seedlings from imported Mazzard pits, and in all cases they have grown with equal vigor, attained as large size, and developed as good root systems. The American Mazzard seedlings which have been grown at this Station during the past five years, while not immune to leafspot infection, appear not to suffer as badly from such infection as do adjoining Frnech Mazzard seedlings. For this reason

the American Mazzard seedlings grow more rapidly, and can be budded over a longer period than the French Mazzard seedlings. In these tests the seedlings received no application of spray to protect them from leafspot. The results should be verified by tests with the same and with other sources of American Mazzard seed before definite conclusions are drawn regarding the resistance of American Mazzard seedlings to diseases.

Provided weather conditions are favorable, cherry pits can be planted in the field in Tennessee any time from early February until late March. If pits are planted early in February, the seedlings are above ground by April. The American Mazzard seedlings appear to grow well on a cherty hillside with stiff red clay subsoil, and sandy alluvial soil, on the banks of the Tennessee River. With good soil and liberal fertilization, the American Mazzard seedlings could be grown to a size large enough to June-bud if that were desirable. On June 20 of this year the writer budded American Mazzard stocks grown from seed planted February 4. As good cherry buds are not generally available at that season, June-budding of cherries is not recommended.

Budding tests of these American Mazzard seedlings have been made at intervals throughout the summer, and they appear to remain in as good condition to bud as do adjoining rows of Mahaleb seedlings. Here again the suggestion is made that workers in other states verify our findings by local tests.

The work has not included a large number of varieties of cherries but buds of Early Richmond, Montmorency and Coe's Transparent put in the American Mazzard seedlings are making as good tops as the same varieties on French Mazzard and on Mahaleb stocks. As the American Mazzard is closely related to cultivated varieties of cherries, it should be equally as good for other varieties as it has proved to be for those we have tested.

More should be done on the problem of reliable sources of the American Mazzard seed than we have been able to do. Careful search in the states where these trees are growing wild would disclose numerous strains, some much better suited for stock purposes. If such strains could be brought together and tested, as Howard and Heppner are testing strains of Myrobalan plums and other stocks in California, we should eventually find here in America Mazzard cherry seed sources equal to, and possibly better than, those in Europe.

The work which the writer here reports shows the possibilities of getting better cherry stocks for which there is a great need in America today. A fair supply of American Mazzard pits collected in Virginia this summer is available, and will be gladly shared with other workers.

Growth Behavior of Apple Seedlings Grown for Nursery Stocks

By T. J. MANEY, *Iowa State College, Ames, Iowa*

IT HAS been recognized for a long time that great variability exists in our standard fruit stock, yet very little work has been accomplished in the development of better lines of stock from seed parents that might show prepotency in transmitting factors which control the development of desirable characteristics in their seedling offspring.

With particular reference to the apple, a study of the literature shows that there is little direct information available which might be helpful in the selection of any particular variety as a seed parent from which to grow stocks. About the only significant data presented are given in the publications of Crandall (1), Lantz (3), Dickson (2), Maney (4), Tukey (6), Yerkes (7), and Roberts (5).

The general unreliability of our standard apple stock, French crab, for the conditions of the upper Mississippi Valley has led a few of the leading nurserymen of Iowa and Minnesota to attempt to remedy the situation by the growing of stock from such hardy local varieties as Charlamoff, Fameuse, Hibernal, Oldenburg, Patten Greening Tetofsky, Virginia crab, Wealthy, Whitney, etc. At the 1928 annual meeting of the Iowa State Nurserymen's Association the writer reported the results of some work which had been carried on in the use of certain varieties as seed parents for the growing of nursery stock. This report resulted in a request by the nurserymen that the work be extended to include a larger number of varieties. Accordingly 57 varieties, including standard and seedling sorts, were selected and the seed was removed by hand from one standard apple boxful, about 40 pounds, of each variety. The seed was removed during the early winter, stratified immediately in damp sand and stored at about 36–40 degrees F. The seed was planted on April 19 and 20, 1929, in a plot of overhead-irrigated heavy Webster silt loam, a type of soil not well suited for the best growth of apple seedlings. The data on growth must therefore be considered only as relative in making comparisons. The seedlings were dug on November 9–11, 1929. In general the wood had matured fairly well by this date. Several heavy frosts had occurred but the leaves still adhered. However, these came off very readily after being buried for a week. After removal to storage a count and an examination were made of the various lots. Top growth measurements were made on 200 seedlings or the entire number from each lot.

The space available for this paper does not permit discussion of all the observations made, but Table I shows the main features of the results. Certain facts are made evident by this table:

1. The amount of seed, which is an important factor in the selection of a seed parent varied greatly with the variety. The standard varieties produced from about 200 to 2800 while the seedling varieties which were selected with some regard to size and seed content averaged higher. One of these, No. 3, (Brier Sweet x Mercer County Crab) averaged about 9000 seeds for 40 pounds of fruit.

2. The germination of the different lots varied greatly, ranging from 6.7 per cent with Charlamoff to 74.2 per cent with Windsor. In our cross breeding work Charlamoff has always produced seed of low germinating ability. The behavior of Hibernal and Virginia crab, two of the hardiest sorts, bears out previous experience with these varieties. Although they are the hardiest and best stocks for double working they are poor seedling producers; they are, however, two of the varieties which might logically be selected for the production of improved stocks.

3. Top growth, because it was a factor which by accurate measurement might be used as an indication of vigor, varied somewhat. However, top growth in itself could not be used to estimate the value of a stock for nursery purposes. The coefficient of variability gives an idea of the percentage of variability which occurred in the top growth of the seedlings of the different lots.

4. The type of root produced was the best indicator of the value of the seedlings for different purposes. Root type can best be expressed in general terms such as "straight" and "branched" or their variations. A seedling for grafting purposes must be straight while branched root seedlings are favored for budding stock. Colorado Orange produced very excellent branch roots while Allen Choice had the longest and straightest root development.

5. Two of the commonest troubles for which apple seedlings are discarded by growers of seedling stocks are wooly aphis and hairy root. Wooly aphis was present on a few of the lots but no definite conclusions can be drawn as to the resistance of the seedlings due to the light infestation. Typical hairy root was present as indicated. No important diseases were evident on the seedlings, and of course nothing could be definitely learned in regard to hardiness, though these are factors which must be considered. Our experience in growing large numbers of cross-bred seedlings has shown that certain varieties, like Jonathan, evidently transmit fire blight susceptibility. It might therefore be expected that Grimes, Esopus, or Tompkins King seedlings might inherit a tendency to collar rot and that there might be a general lack of hardiness in seedlings of Stayman, Delicious or Ben Davis. At least no northern nurseryman could be induced to grow seedlings of the latter varieties even though the seedlings grown under investigation might be perfect.

Conclusions from the data which are included in Table I must be influenced by the behavior of our well-known standard stock, French crab. Comparisons made against this stock in regard to germination, top and root growth, and an estimate of hardiness show that seedlings of certain standard and seedling varieties are superior to it. No comparison can be made with it in regard to seed production, but the difference between the varieties in this respect is a feature which is brought out very strikingly in Table I.

It is clearly shown that certain varieties possess merit and others abound with faults as seedling producers. The behavior of Windsor, Allen Choice, and Brier Sweet x Mercer County crab as seedling producers is outstanding; Windsor, because of its high seed content, high germination and good roots; Allen Choice, because of its ex-

TABLE I—GROWTH CHARACTERISTICS OF APPLE SEEDLINGS.

Variety, Ames Seedlings	No. Seeds Planted	No. Seeds Grew	Percentage Stand	Mean Height Inches	Coef. of Var.	Root Type	Remarks
1. Anisim Selfed 5–13–22	1186	389	32.8	8.6	36.5	Br.	Poor
2. Ben Davis x Pat Gr. 5–10–29	589	292	49.6	12.3	25.6	Str.	Hairy root
3. Brier Swt. x Mercer Co. 5–13–33	16000	8251	51.6	9.0	34.8	Str.	Good sdlgs.,* early maturing, leaves off Nov. 7
4. Brilliant x Malinda 5–7–12	465	174	37.5	11.7	27.5	Br.	Fair
5. Brilliant x Malinda 5–7–19	1601	582	36.3	9.6	31.5	Br.	Fair
6. Longfield x Gano. 5–0–32	1386	511	36.9	9.0	32.2	Br.	Hairy roots
7. Longfield x Gano. 3–15½–40	870	290	33.3	9.9	26.1	Br.	Hairy roots, poor
8. Longfield x Gano. 5–0–17S	838	291	34.7	9.8	31.8	Br.	Fair
9. Longfield x Mt. Beet 4–9–19S	1183	334	28.3	9.8	24.1	Br.	Spindly, late maturing
10. McIntosh x Longfield 6–2–22	2125	275	12.9	8.8	27.2	Br.	Fair
11. Mo. Pippin Ung 6–0–33	1643	529	32.1	9.0	29.7	Br.	Poor, variable
12. Patten x Jonathan 5–11–33	945	390	41.3	9.1	31.0	Br.	Very poor, branched spindly tops
13. Patten x Jonathan 5–11–36	1385	504	36.4	11.0	26.3	Br.	Poor, branched tops
14. Tolman x B. Davis 6–2–1	459	232	50.6	11.9	23.0	Str.	Very good
15. Vt. Seedling 3–1–4N	749	422	56.3	12.2	24.7	Str.	Stocky, good
Standard Varieties							
16. Allen Choice	920	404	43.9	9.8	36.0	Str.	Spindly, longest roots
17. Anisim	406	119	29.3	10.8	24.8	Str.	Fair
18. Antonovka	743	264	35.5	10.0	31.6	Str.	Wooly aphis, good roots
19. Baltimore	1317	481	36.5	12.0	25.6	Br.	Very spindly
20. Ben Davis	700	127	18.1	10.6	32.0	Str.	Fair
21. Bogdonoff Glass	319	152	47.7	9.6	29.6	Str.	Good stock
22. Charlamoff	2632	177	6.7	10.0	**		
23. Colorado Orange	831	438	52.8	10.0	32.5	Br.	Good branch, root type
24. Deickman	504	284	56.4	8.1	37.0	Str.	Fair
25. Delicious	590	329	55.8	8.7	32.1	Str.	Slight wooly aphis
26. Eden Crab	1633	280	17.2	7.1	39.7	Str. to Br.	Good crab type
27. French Crab	3300	1816	55.0	9.6	30.3	Str.	Very variable
28. Gano	967	400	41.3	10.3	30.8	Str.	Spindly

29. Green Mercer	145	15	10.4	4.8	34.5	Br.	Very poor
30. Grimes	941	230	24.4	8.4	41.7	Str.	Poor
31. Hibernal	409	115	28.1	5.7	44.4	Br.	Very poor
32. Hutchins Red	943	188	20.0	10.1	22.5	Str.	Hairy root
33. Jonathan	805	410	51.0	10.1	32.1	Str.	Wooly aphis
34. Kinsman	1077	653	60.5	9.8	28.4	Str.	Good
35. Longfield	248	62	25.0	7.8	34.0	Str.	Hairy root
36. M. Niedzwetzkyana	474	181	38.2	11.3	23.7	Br.	Variable, poor roots, branched tops
37. Malinda	2780	686	24.7	8.9	37.2	Br.	Poor
38. Missouri Pippin	1390	622	44.8	9.3	35.2	Str.	Variable, spindly
39. McIntosh	194	92	47.3	10.5	31.0	Str.	Hairy root
40. McMahon	819	413	50.3	10.7	33.4	Str.	Fair
41. N. W. Greening	1374	504	36.7	8.8	37.1	Br.	Fair
42. N. Spy	654	184	28.2	9.5	29.9	Str.	Good roots
43. Okoboji	1293	359	27.8	11.3	26.7	Br.	Very branched tops
44. Oldenburg	1053	579	54.8	9.8	28.2	Str.	Good roots
45. Paradise Winter Sweet	263	135	51.3	12.0	21.0	Br.	Very good branch type
46. Pewaukee	742	349	47.1	10.4	29.9	Str.	Excellent roots
47. Ralls	2004	894	44.6	10.5	27.8	Br.	Fair
48. Red Astrachan	801	186	23.2	10.0	24.5	Str.	Good
49. Red Mercer	1121	154	13.7	7.2	38.4	Br.	Very poor
50. Salome	728	213	29.3	10.4	32.9	Br.	Fair
51. Sharon	538	234	43.5	10.5	23.6	Br.	Good
52. Stayman	483	60	12.4	8.1	39.9	Br.	Poor
53. Tolman	306	187	61.1	10.4	25.6	Str.	Very excellent for grafting
54. Virginia Crab	1025	125	12.2	5.3	34.6	Str.	Very poor
55. Wealthy	1074	562	52.3	10.7	28.8	Str.	Very good
56. Whitney	1030	631	61.3	8.1	35.9	Str.	Some wooly aphis, very good sdlgs.
57. Windsor	1596	1186	74.2	11.2	26.4	Str.	Some wooly aphis, very good sdlgs.
58. Winter Banana	875	418	47.8	10.0	30.7	Str.	Some wooly aphis, spindly fair sdlg.
59. Wolf River	369	106	28.7	11.1	25.0	Str.	Stocky, very good
Total	71208	29293	41.1	9.7	30.7		

*2 bu. fruit produced approximately 18,000 seeds.
**Seed Number indicated from 2 bushels hand pollinated fruit not included in totals.
Str. =Straight root. Br. =Branched root.

ceptionally long straight roots; and Brier Sweet x Mercer County crab, because of its remarkable seed content, its average germination, good roots, and its ability to ripen its wood and shed its leaves at an early date. The latter characteristic is indicative of hardiness and adaptation to environmental conditions. Seedlings of this cross when grown during the past season by Professor J. A. McClintock at Knoxville, Tennessee, attained a growth of 3 to 4 feet and were the most resistant to any visible evidences of wooly aphis or any of several lots of seedlings growing with them. Investigators interested further in this variety are referred to a previous account of it made by the writer (4). Seedlings of other varieties were outstanding in their faults. Of these Charlamoff, Grimes, Hibernal, Stayman, Virginia and certain native crab types indicated as Red and Green Mercer and Eden crab are examples.

From the data presented it is obvious that the problem of developing new lines of seedling stocks from standard and seedling varieties presents a wide field for investigation. The work should be extended by the use of a long list of varieties grown under a wide variety of conditions. In the event that nurserymen in the future may be obliged to raise domestic stock then such information will be of great value in the selection of the best varieties for the establishment of seed orchards.

Literature Cited

1. Crandall, Charles S. Seed production in apples. Ill. Agr. Exp. Sta. Bul. 203. 1917.
2. Dickson, George H. Variability of vigor in apple seedlings. Proc. Amer. Soc. Hort. Sci. 165. 1928.
3. Lantz, H. L. Apple breeding. The vigor of Antonovka seedlings. Proc. Amer. Soc. Hort. Sci. 115. 1927.
4. Maney, T. J. A search for better nursery stocks. Trans. Ia. Hort. Soc. 63: 188. 1928.
5. Roberts, R. H. Some stock and cion observations on apple trees. Wis. Agr. Exp. Sta. Res. Bul. 94. 1929.
6. Tukey, H. B. Seedling fruit stocks. N. Y. State Agr. Exp. Sta. Bul. 569. 1929.
7. Yerkes, Guy E. Propagation of trees and shrubs. U. S. D. A., Far. Bul. 1567. 1929.

Propagation of the Low-Bush Blueberry

By A. C. HILDRETH, *Experiment Station, Orono, Maine*

MAINE blueberries yield the growers annually over half a million dollars, and the canned pack is valued at close to two million dollars. This crop is all produced from native low-bush species, mostly *Vaccinium pennsylvanicum* Lam. and *V. canadense* Kalm. The plants are essentially wild. There are no named varieties and no attempt is made at propagation, planting, cultivation, or any of the other generally recognized horticultural practices. Many circumstances are tending to change blueberry growing from an extensive to an intensive type of culture. Chief among these are the market demand for a better canned product and the necessity of dusting or spraying to control the blueberry maggot and other pests.

For the past two years the Maine Agricultural Experiment Station has been attempting to improve the horticultural status of this fruit. The first essential for either commercial grower or investigator is a cheap and reliable method of propagation. Under proper conditions blueberries grow readily from seed but as they do not breed true, asexual propagation must be practiced.

Fortunately the low-bush types are well adapted to vegetative multiplication. In most bush fruits the stem is aerial and vertical, but in the low-bush blueberry the bulk of the stem is subterranean and horizontal, forming a dense net-work in the soil. The above-ground parts commonly thought of as the stems are merely terminal or lateral shoots from these underground-stems or rhizomes. Coville (2) and Brierley (1) have indicated that these underground-stems might be used for propagation. Preliminary greenhouse tests with rhizome cuttings showed as high as 98 per cent rooting. These results led to the adoption of this method for nursery work and it is now believed to be suitable for commercial nursery practice.

In this method the clone to be propagated is cut into strips and taken up much like turf is handled for sodding lawns. The soil is shaken off and the rhizomes cut into 3-inch lengths. From a square foot of such "sod" 220 cuttings have been made. In the nursery these cuttings are laid end to end in furrows about 6 inches apart and covered with about 2 inches of soil. Under Maine coast conditions no shading or artificial watering has been necessary. Spring planting seems better than fall, because the cuttings may heave out of the ground over winter. After one season's growth in the nursery row the plants can be set in the permanent location.

Apparently any part of the rhizome may be used for propagation, but smaller diameter cuttings are more likely to grow. The accompanying data are from a preliminary test on the rooting of different classes of rhizome cuttings:

Class	Per cent rooting	Class	Per cent rooting
Large diameter with tops attached	67.2	Medium diameter	92.1
Large diameter	85.8	Small diameter	96.1

The inferiority of the larger cuttings is probably due to the smaller number of active rootlets. In those with tops attached, the larger evaporating surface may also be a factor.

The importance of the propagating medium for stem cuttings of high-bush blueberries has been stressed by Coville (3) and Johnston (4). For the low-bush rhizome cuttings the best medium found is the light sandy or gravelly loam soils in which these blueberries grow naturally. In out-door work peat dries out too quickly, probably because its open texture permits free air circulation and also inhibits capillary rise of water from below. To test the merits of peat, two nursery beds were prepared side by side. One had only the native blueberry soil, the other was excavated to a depth of six inches and filled with granulated peat, thoroughly wetted and packed down. In this instance peat as a propagating material was decidedly inferior to soil, as is shown below.

Medium	Number cuttings planted	Per cent rooting
Peat	303	80.5
Soil	300	94.7

Propagation of low-bush blueberries can be accomplished also by the usual type of stem cuttings; however, since these aerial stems are a small part of the plant, increase by this method is slow. Furthermore, special propagating frames or greenhouses are necessary to control temperature and humidity. A cool temperature seems to be especially important. During fall and winter, cuttings rooted readily in a cool greenhouse. However, during spring and summer when the greenhouse temperature could not be kept down, stem cuttings often failed completely. These differences occurred irrespective of the stage of development of the shoots from which the cuttings were made. Studies on temperature relations are being continued.

Growth of blueberry seedlings or newly rooted cuttings is greatly stiumlated by application of some readily available source of nitrogen, as sodium nitrate or ammonium sulphate.

Literature Cited

1. Brierley, W. G. Blueberry culture in Minnesota—A report of progress. Proc. Amer. Soc. Hort. Sci. 243–249. 1920.
2. Coville, F. V. Experiments in blueberry culture. U.S.D.A. B. P. I. Bul. 193. 1910.
3. ————. Directions for blueberry culture. U.S.D.A. Bul. 974. 1921.
4. Johnston, Stanley. Investigations in rooting blueberry cuttings. Proc. Amer. Soc. Hort. Sci. 181–182. 1928.

Marianna Plum Seedlings Versus Rooted Cuttings as Root Stocks

By J. A. McClintock, *University of Tennessee, Knoxville, Tenn.*

WITH the Federal quarantine upon us and with an inadequate supply of American Myrobalan plum seed available, American nurserymen need a native source of plum stocks to tide them over until they can adjust themselves to the changes. Peach seedlings are offered as a substitute for Myrobalan plum stocks, but they will not prove satisfactory where the roots are subjected to the extreme cold of the North, or the root-knot nematodes of the South.

The work of Howard and Heppner as reported to this Society in 1928 gives hope of better strains of Myrobalan plums, but it will be some time before their improved stocks are generally available. The native Chickasaw plum offers an abundant source of stocks, but its susceptibility to the dreaded peach rosette disease of the Southern States, together with its tendency to sucker, and its poor unions with other species make a better plum stock desirable.

The Marianna plum, originated in Texas, has been used extensively as a root stock for years. Its immunity to root-knot nematodes and to peach rosette make it desirable. The ease with which the cuttings of Marianna are rooted has resulted in clonal lines of stocks which have different habits of growth from seedling stocks. To overcome some of the undesirable characteristics of stocks from rooted cuttings and yet to take advantage of this American stock, of which there is a considerable source of available pits, the writer has been studying Marianna cuttings in comparison with home-grown Marianna seedling stocks.

In 1924 the writer presented to this Society observations regarding the sudden dying of peach trees growing on Marianna plum root stocks. The question was raised whether this was due to faulty union, fungus infection of the roots, or uncongeniality between the stock and the scion. In 1925 additional data were presented to this Society showing that peaches growing on Marianna plum roots died because of uncongenial unions between the peach and the plum stocks. Peach trees on peach roots and Marianna plum trees from rooted cuttings were set in 1924 in the holes from which the dead trees were removed. These have grown normally for six years and have produced crops of fruit for the past two years. This proves that the fungi associated with the dead plum roots in 1923 are not capable of attacking healthy plum and peach roots.

Five trees of the original lot of peaches on Marianna plum root stocks set in 1923 are still alive. Four appear to be as vigorous as peaches of the same age on peach roots; while one which is stunted and weak appears to be malnourished. As stated in the 1925 report, three of the five trees which died during that year had developed a few small roots from the peach trunk just above the union with the Marianna plum stocks. On November 7, 1929, when one of the four remaining vigorous trees was dug it was found that all of the

roots which were sustaining the peach top had developed from the peach trunk above the union and this peach tree was entirely upon its own roots. The greatest spread of peach roots was more than 26 feet. All that was left of the Marianna plum stock was a short dead stub. On sawing longitudinally through the union it was found that the plum stock had made little growth and had died probably during the second season after setting. During the first two years the elaborated plant food piled up at the base of the peach trunk just above the union stimulated the growth of sufficient peach roots to make this tree self sustaining. While it seemed best not to dig the other three vigorous trees, their growth in comparison with the tree which was dug would indicate that they too are well established on their own peach roots. These records give further confirmation of the belief that peaches can not be successfully grown on Marianna plum rooted cuttings as stocks. As soon as the peaches become established on their own roots they are as susceptible to root-knot as peaches on seedling peach roots.

In their report to this Society in 1928 Howard and Heppner presented similar data confirming the uncongeniality of peaches on rooted cuttings of the Marianna plum. From studies with Myrobalan seedlings, they infer that Marianna seedlings may be found which are more congenial to the peach than the clonal lines now in use as stocks. If such seedlings retain the nematode and rosette resistance of their clonal parents they will be the basis for the starting of new clons superior to the existing ones.

Although the Marianna plum has been extensively used as a root stock for plums, in recent years its use has been on the decline. Inquiries among nurserymen as to the cause of this disclosed the fact that the cuttings produce a broad, shallow root system not equivalent to roots produced by Myrobalan stocks grown from seed.

In Bulletin 498 of the New York State Experiment Station, Hedrick states with reference to the Marianna stock "Unfortunately the resulting tree on this stock is not as long lived, vigorous, and productive as is desirable." As the Marianna plum stocks used in the Geneva Station tests were from cuttings, as stated in this bulletin, these references to the length of life and lack of vigor may be due to the use of such shallow-rooted stocks.

In test plantings of plum stocks set in 1924, Marianna trees from rooted cuttings have kept pace in growth and vigor with Myrobalan seedlings imported directly from France. The Myrobalan seedlings have not only been slower in coming into bearing, but also vary greatly in size and dates of maturity of fruit. On the whole they would be considered poor yielders in comparison with the Marianna trees of the same age. The Marianna trees grown from cuttings for many years are nearly uniform in fruit production and time of ripening. Since the fruits of the Marianna average only an inch in diameter and are of inferior quality, they are unsatisfactory for commercial use as fresh or canned fruit. However, early and regular bearing makes this plum a desirable variety to raise for pits. Another point in its favor is that Marianna seed is more nearly uniform than any commercial lot of Myrobalan seed which the writer has seen imported from Europe.

Tests by the writer with imported Myrobalan seed have not been uniformly good. This was probably due to the dryness of the pits, and to the fact that they were received too late for stratification before planting. Much better germination has been obtained with seed from French Myrobalan trees fruited in the Station test plats, which were not allowed to dry as are the imported pits. The Marianna pits from our test trees, handled in a manner similar to the home grown Myrobalan pits, gave equally good germination. The seedlings of the two species grew equally well in the nursery rows, and both Marianna and Myrobalan seedlings outstripped Marianna cuttings in growth. The seedlings were large enough to bud at the time peach seedlings are generally June budded, while the Marianna cuttings were considerably slower in their growth. Up to the dormant budding season, the Marianna seedlings had kept pace with Myrobalan seedlings in growth. Both lots of seedlings were far in advance of Marianna cuttings set at the same time the seed was planted; i.e., February 4. The Marianna seedlings had straight, smooth trunks, and required the same pruning as Myrobalan seedlings preparatory to budding. Buds could be inserted in these stocks at any desired height above ground. The Marianna cuttings required considerable pruning. In some cases the buds had to be inserted in the original cuttings, while in others a new shoot was large enough to bud. In order to bud the original cutting it was often necessary to dig the soil away, as many of the buds were inserted below the surface. This slowed up the budding considerably.

During the summer of 1929 adjoining rows of Marianna cuttings and seedlings were budded to several cultivated varieties of plums. The cuttings were much slower in reaching a condition suitable for budding, and weather changes affected them more quickly than it did the seedlings. A short period of hot, dry weather tightened the bark on the cuttings so that it was difficult to insert buds. Marianna seedlings continued in good budding condition throughout the hot, dry weather. Subsequent counts on adjoining rows indicated that a better set of buds was obtained on the seedlings. These observations on the superiority of the seedlings indicate that the deeper rooted stocks are better in the nursery row. That the shallow root habit of the Marianna cuttings continues after these stocks are transferred to permanent locations is revealed by digging a block of six-year old trees at the University farm. In all cases these trees had a spread of roots beyond the tips of the branches, but in no case had the roots penetrated the subsoil.

Although much remains to be done in adapting the Marianna plum as a root stock for peaches, it is a good stock for various cultivated plums. If the shortcomings pointed out by Hedrick are due to the use of rooted cuttings, these objections may be overcome by the use of Marianna seedlings.

The writer expects to continue tests to determine the resistance of the Marianna seedlings to nematodes and rosette, but with the available land, orchard test plantings can not be made to determine the ultimate value of Marianna seedlings as stocks for plums and peaches. Therefore, this preliminary report is presented with the hope that others may carry the work farther.

Influence of Size of Mahaleb Seedlings on Nursery Grades

By C. L. BURKHOLDER and LAURENZ GREENE, *Purdue University, Lafayette, Ind.*

GROWERS of sour cherry nursery stock are interested in securing a more uniform distribution of their one year trees in the higher nursery grades. A difference of $\frac{1}{16}$ inch near the dividing line between grades will make as much as ten cents difference in the sale price of the tree. Number one trees as now classified must be $\frac{11}{16}$ inch or more in diameter. With a small increase in growth a considerable percentage of number twos ($\frac{9}{16}$ to $\frac{11}{16}$)would become number one trees.

The practice among Indiana nurserymen is to buy seedlings, grow them in the nursery row one season and bud them in late summer. The seedling is cut off above the bud early the following spring. The bud is allowed to grow one season and is dug and sold at the end of that time as a one year tree.

In October of 1928 several hundred recently budded Mahaleb seedlings were calipered just below the Montmorency bud to permit an accurate study of the influence of fertilizers on the resulting stock. This material offered opportunity to study the effect of the size of the seedling upon the resulting grade of one year old cherry trees.

A total of 1191 individual trees were measured in October of 1928 and again in 1929.

The seedlings were unusually fine and the resulting nursery stock was equally high grade. The soil was in a high state of fertility so that quantitatively the results secured might not be duplicable in later trials. It is possible that qualitatively they might be duplicated.

On this type of soil ammonium sulphate applied in October 1928 gave no consistent results in 1929 so far as size of tree was concerned.

Among the 1191 seedlings, 385 were below 8/16 inch in diameter in 1928. Only 20 per cent of these produced number one trees, ($\frac{11}{16}$ or above) in the fall of 1929.

Of 806 seedlings 8/16 inch or more in diameter in the fall of 1928, over 82 per cent produced trees $\frac{11}{16}$ inch or more in diameter in the fall of 1929.

The correlation coefficient between size of seedling in 1928 and size of tree produced in 1929 was .685 with a probable error of $\pm$.0158. The resulting curve is not a straight line, as it tends to flatten out with larger trees.

Tukey reported in New York State Station Bulletin No. 569 that the larger French Pear seedlings and French Crab seedlings produced the highest percentages of "Extra" grades (over ¼ inch) during the second season.

Sax reported to this Society in 1923 that he secured correlation coefficients from .26 to .43, depending upon variety of apple cions used, between the caliper of apple seedling in 1922 when budded and the size of whip in 1923.

The results reported in this paper are in accord with the height of tree data published by Roberts in Wis. Sta. Res. Bul. 94 (1929), and the resulting curve is similar in form to the curves shown by him in that publication.

In studies of fertilizers or other varied factors averages of final size of stock may not be significant unless individual seedling measurements are recorded also.

Improvement of nursery stock may depend quite as much upon the growing conditions during the seedling stage as upon the growing conditions or treatment during the year the bud is growing.

The Growth of Plants and the Development of Chlorophyll as Influenced by Selective Solar Irradiation

By CHARLES SHEARD, G. M. HIGGINS, and W. I. FOSTER,
Rochester, Minn.

The material contained in this paper will probably be published in the Journal of Plant Physiology.

Nematode Resistance of Certain Peach Seedlings

By WARREN P. TUFTS, *University of California, Davis, Calif.*

ONE of the limiting factors in the commercial production of peaches in the great San Joaquin Valley of California is the soil nematode (*Heterodera radicicola*). The soils of this valley are characteristically rather light and sandy and nematodes are widely distributed.

Apparently the most practicable way of circumventing the trouble is to find a rootstock highly resistant or immune to nematode attack. McClintock (1) has reported Marianna plum, wild plum and cultivated plum seedlings as resistant; however, in California as well as in other sections (2) the plum has not proved a congenial stock for peach. Milbraith (3) has reported seedlings of the Myrobalan plum and *Prunus davidiana* as susceptible to nematode attack. The apricot root has generally been accepted as immune to nematodes; however, H. R. Keller of Fresno, California, this past season reports a case in which apricot roots have been attacked. At all events, the numerous attempts which have been made to work the peach on the apricot have in most instances been attended with indifferent results. Many growers are of the opinion that if the peach is propagated rather high (8 or 10 inches) on the stock, or if the apricot is allowed to grow and later topworked, the union will be more satisfactory. The California Experiment Station is at present investigating this problem.

McClintock (4) reported that resistance to root-knot nematode was seed-transmitted. Taking this experience as a working basis, M. J. Heppner, formerly with the Division of Pomology of the University of California, collected seeds of 133 named peach and nectarine varieties. These seeds were planted in the nursery and after a season's growth moved to a piece of ground near Escalon, California, very heavily infested with soil nematodes. In the fall of 1928, after a season's grow in the nematode soil, the trees were dug and carefully examined for the typical nematode root-knot. The 4,663 seedlings were classified as follows: heavily infested, 1,594; moderately, 1,357; lightly (1–2 knots) 914; no visible infestation, 798.

The fact that more than 17 per cent of the seedlings tested showed no visible infestation should not be taken as meaning that this number were resistant. Probably most of these seedlings stood in spots where the nematodes were not numerous. As many replications were made as the number of seedlings available permitted. In certain areas a given variety, and in fact many varieties, showed no infestations and still in other locations these same varieties were seriously damaged.

In future work, it is planned to grow susceptible seedlings adjacent to the seedlings being tested for resistance. Furthermore, having now rather definitely mapped seriously infested areas, as shown by root-knots on susceptible sorts, further tests will be made more reliable by placing the new plantings in these same infested spots.

The Bokhara, a variety introduced by the late J. L. Budd as a hardy sort from pits from Bokhara, Russia, was the only one of the 133 varieties tested in 1928 which showed during the one year of its test practically no infestation. The 27 seedlings of this variety

happened to be planted in one of the most heavily infested spots as shown by the amount of infestation of other seedlings on all sides, Fig. 1, and yet 25 of these showed not a single knot, the other two falling one into class 3 with one or two knots, one into class 2.

Thirty additional peach varieties were tested during the summer of 1929 on a piece of soil at the University Farm which is infested with nematodes. Only 329 seedlings were involved in this trial, many varieties being represented by a very few seedlings. As a result of this test the Shalil (S. P. I. No. 36485) gives distinct promise

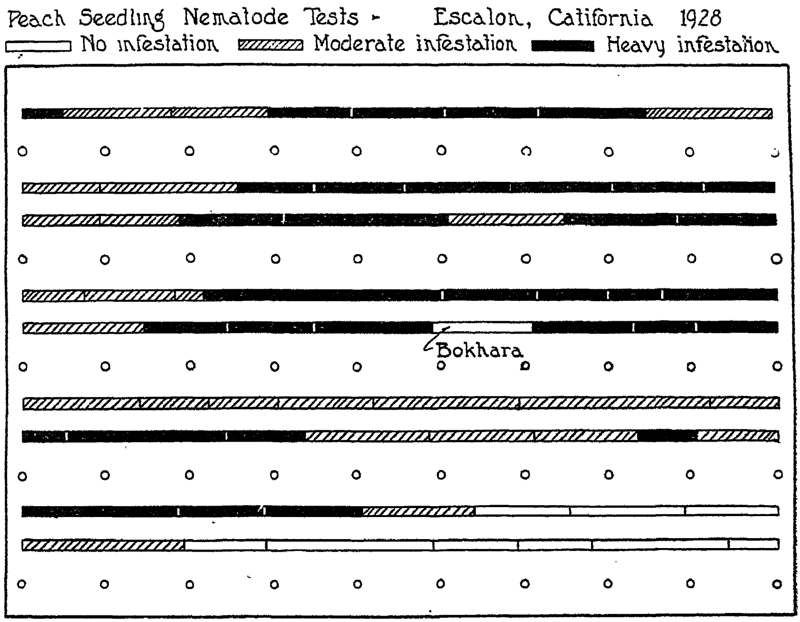


FIG. 1. Showing the field resistance of Bokhara seedlings as compared with seedlings of other varieties.

and will be tested further. This variety, introduced by the Bureau of Plant Industry from Northwestern India, is a very thrifty grower of fine habit and its fruit will undoubtedly have some value as a dried product. The Bokhara on the other hand, although a satisfactory grower and probably giving as much promise as a rootstock resistant to nematodes, may be handicapped because of the low commercial value of its white-fleshed fruit.

The Honey and the Saucer types of peaches have been credited with resistance to the root-knot nematode. Seedlings of varieties growing under the names of Honey, Luken's Honey, and Australian Saucer were included in the tests reported. Although these seedlings showed a somewhat higher resistance than the general average they fell far behind the Shalil and Bokhara in this respect.

Literature Cited

1. McClintock, J. A. Report on resistant plants for root-knot nematode control. Georgia Agr. Exp. Sta. Cir. 77. 1922.
2. Anonymous. Horticultural investigations at the Georgia Coastal Plain Station. Georgia Coastal Plain Sta. Bul. 8. 1927.
3. Milbraith, D. G. Root-knot nematode in relation to deciduous fruit trees and grape vines. Calif. Dept. Agr. Bul., Vol. 12:127. 1923.
4. McClintock, J. A. The transmission of nematode resistance in the peach· Science, N. S. 58:466. 1923.

The Relationship Between Tree Age and the Rooting of Cuttings

By F. E. Gardner, *University of Maryland, College Park, Md.*

NOTWITHSTANDING the numerous helpful researches dealing with the propagation of plants by cuttings, such as, the most favorable conditions as regards media, moisture, light, temperature, and other factors external to the cutting, relatively very little is known concerning the internal factors or principles involved in root regeneration which can be applied in a practical way toward the solution of the many problems in this phase of plant propagation. The rooting response of a certain type of cutting reported in this preliminary paper seems to offer an unusual opportunity to learn something concerning the nature of these fundamental internal conditions.

During the winter of 1927–28, while attempting to grow stem cuttings of apple, it was found quite by chance that if the apple cuttings were taken from one-year-old seedlings very little difficulty was encountered in getting them to root. On the other hand if the cuttings came from seedlings which were two or more years old, even though one-year-old wood was used, almost as great difficulty was experienced in getting them to root as in the case of named varieties. So striking was the difference in rooting response between cuttings from one-year-old and older seedlings, grown under exactly the same conditions, that it was decided to ascertain if this difference was peculiar to apple or characteristic of other species as well.

In testing the rooting ability of cuttings from trees of different ages, material was selected to give as fair a comparison as possible. One-year-old wood was taken from the different ages of a species which had grown side by side or at least under similar conditions. The cuttings within a species were made at the same time, placed in the same medium in the greenhouse, and given the same treatment. Sand was used as the propagating medium for all species except holly, in which case a fifty-fifty mixture of peat-moss and sand was used. No particular care was exercised in watering the cuttings or in heating or ventilating the propagating house. Since many species have rather definite requirements not only in regard to water and temperature, but also with respect to the season of the year when the cuttings are taken, some of the percentages of rooting in the older trees given in the following table may appear to be low. They are, however, to be compared with the percentages of rooting found in the case of one year old trees.

It can be observed from the table that nearly every species worked with has rooted better from very young seedlings than from older trees. To date no species has failed to root from cuttings of one year old seedlings. Although it is well known that such plants as cherry, apple, and locust, even under very carefully controlled conditions, are difficult to root from hardwood cuttings, the results of this study show a fairly high percentage of rooting when the cuttings are taken from one year old seedlings.

TABLE I—THE ROOTING RESPONSE OF CUTTINGS FROM SEEDLINGS OF DIFFERENT AGES.

Species	Age of Tree	No. of Cuttings	Per cent Rooted
Pyrus communis (French pear)	1 yr.	96	64*
Pyrus communis (French pear)	2 yrs.	79	13
Pyrus malus (French crab)	3 months**	125	98
Pyrus malus (French crab)	1 yr.	131	75
Pyrus malus (French crab)	2 yrs.	207	10
Pyrus malus (French crab)	3 yrs.	236	1
Prunus avium (Mazzard cherry)	1 yr.	149	22
Prunus avium (Mazzard cherry)	2 yrs.	142	6
Prunus mahaleb (Mahaleb cherry)	1 yr.	232	43
Prunus mahaleb (Mahaleb cherry)	2 yrs.	164	7
Prunus cerasifera (Myrobalan)	1 yr.	234	97
Prunus cerasifera (Myrobalan)	2 yrs.	119	29
Prunus persica (Peach)	1 yr.	183	6
Prunus perisca (Peach)	2 yrs.	98	11
Ulmus americana (American elm)	1 yr.	100	42
Ulmus americana (American elm)	2 yrs.	144	50
Ulmus americana (American elm)	old***	43	26
Ulmus pumila (Chinese elm)	1 yr.	70	86
Ulmus pumila (Chinese elm)	12 yrs.	80	39
Acer dasycarpum (Silver maple)	1 yr.	143	99
Acer dasycarpum (Silver maple)	2 yrs.	164	84
Acer dasycarpum (Silver maple)	old	152	3
Acer saccharum (Sugar maple)	1 yr.	90	20
Acer saccharum (Sugar maple)	old	55	0
Ilex opaca (American holly)****	1 yr.	12	100
Ilex opaca (American holly)	2 yrs.	45	64
Ilex opaca (American holly)	3 yrs.	38	47
Ilex opaca (American holly)	old	50	0
Robinia pseudacacia (Black locust)	1 yr.	48	71
Robinia pseudacacia (Black locust)	old	80	0
Catalpa speciosa (W. catalpa)	1 yr.	50	100
Catalpa speciosa (W. catalpa)	old	57	77
Amorpha fruticosa (False indigo)	1 yr.	75	89
Amorpha fruticosa (False inigo)	2 yrs.	54	88
Amorpha fruticosa (False indigo)	5 yrs.	56	89
Pinus sylvestris (Scotch pine)	1 yr.	90	77
Pinus sylvestris (Scotch pine)	2 yrs.	80	8
Pinus sylvestris (Scotch pine)	3 yrs.	52	0
Pinus strobus (White pine)	1 yr.	101	98
Pinus strobus (White pine)	2 yrs.	90	51
Pinus strobus (White pine)	3 yrs.	64	12
Pinus resinosa (Red pine)	1 yr.	150	62
Pinus resinosa (Red pine)	2 yrs.	116	3
Pinus resinosa (Red pine)	3 yrs.	102	7
Pinus taeda (Loblolly pine)	1 yr.	112	46
Pinus taeda (Loblolly pine)	2 yrs.	107	6
Pinus taeea (Loblolly pine)	3 yrs.	122	0
Thuja occidentalis (A. arborvitae)	2 yrs.	52	100
Thuja occidentalis (A. arborvitae)	old	60	42
Picea excelsa (Norway spruce)	2 yrs.	56	90
Picea excelsa (Norway spruce)	old	40	50
Taxodium distichum (Bald cypress)	1 yr.	45	95
Taxodium distichum (Bald cypress)	2 yrs.	56	30
Taxodium distichum (Bald cypress)	3 yrs.	48	10

*The decimal has been dropped in favor of the nearest whole number.

**Seedlings germinated and grown in sand without nutrients. Soon ceased growth and hardene up. Leaves left on cuttings. Other apple cuttings were from dormant field grown plants.

***"Old" indicates at least over ten years.

****After 4 weeks time. Rooting not completed.

Peach, in the only test made thus far, has proved to be an exception. The poor rooting from cuttings of one-year-old peach seedlings may possibly be explained by the habit of the tree to branch and re-branch so that it is somewhat comparable in form to a tree of most any other species several years old. It was from the outermost branches that the cuttings in this case were made. *Amorpha fruticosa* (false indigo) has also failed to give better rooting from one-year-old seedlings. This species, however, is a particularly free-rooting one and a quite satisfactory percentage was obtained from all ages of tree.

The pines, altho fairly readily reproduced by seed, are ordinarily considered very difficult to propagate by cuttings. It was found, however, that cuttings of one-year-old pine seedlings root quite readily and that the ease of rooting falls off rapidly with increasing age of the tree. Some forest tree nurserymen have observed that seedling pines, the stems of which have been cut off just below the surface of the ground by grubs, often produce new roots and survive, provided soil moisture in the upper levels is not lacking. These nurserymen no longer worry greatly about grub injury in their seedling beds.

Not only is there a higher percentage of rooting among the cuttings from one-year-old seedlings but the time required for rooting to occur is much shorter. The holly cuttings from one-year-old trees listed in the preceding table were removed from the propagating medium at the end of four weeks and were found to be 100 per cent well rooted, whereas there were no roots on any of the cuttings from an old tree within the same length of time. The roots in the former case must have started to appear at least within three weeks from the time of taking the cuttings. Unfortunately there were only 12 cuttings in this group which were strictly comparable with those from two- and three-year-old plants. However, in another group of 50 cuttings from one-year-old seedlings, 64 per cent have rooted at the time of this writing. Cuttings of one-year-old apple seedlings have rooted in ten days time, and all other species tried have materially reduced the period necessary for root production as compared with cuttings from older trees.

The response can not be attributed to the proximity of the basal end of the cutting to the seedling root tissue and therefore the possibility of including some of the root tissue with the cutting, or to benefit of any etiolation effect to the lower portion of the stem due to being covered with soil while growing, for in all cases the cuttings were purposely taken high enough above the root and the surface of the ground to avoid these effects. However, a number of explanations of the decrease in rooting ability as the tree grows older suggest themselves. The fact that cuttings from apple varieties which have grown one year from the bud (i. e. one year nursery trees) fail to root just as completely as cuttings from older trees, suggests that it is the age of the tree from the *seed* and not from the bud which is important. This seemed to indicate that the seed might play some important part. It was at first thought that perhaps the seed contained some property or substance which, carried

over into the one-year-old seedling, enabled it to root from cuttings, and that as the seedling grew larger in top and root this substance, being in definite quantity, became proportionately less in any part of the plant so that a cutting from a two-year-old tree would contain very much less of that substance than a cutting from a one-year-old, and there would be still less in a cutting from a three-year-old, and so on. From the standpoint of effecting a remedy for the situation this was of course a discouraging point of view, for it meant that the tree could never be obtained again in a condition as favorable for the rooting of cuttings as in its first year.

This rather mysterious hypothesis, however, was soon discarded when it was found that if one-year-old apple seedlings are cut back to the ground, the growth of the second year can then be rooted and in some cases even more readily than that of the first year. This definitely eliminated the importance of a root-producing substance carried over from the seed. Moreover, apple cuttings from older trees still failed to root after being soaked and injected with extracts prepared from germinating apple seeds.

On first thought it seems of very little value to learn that one-year-old seedlings root easily from cuttings, for in most cases only one stem cutting can be obtained from a plant. Why, then, destroy the seedling top when it is possible to secure as a maximum return only one rooted cutting? Altho some benefits, at present unforeseen, may develop directly from the application of this response, the chief importance lies not so much in the fact itself as in the underlying principle. If it can be definitely ascertained why cuttings from one-year-old seedlings root easily it may then be possible to bring older trees into the same desirable condition. If older trees can be so modified it is obviously important not only in making possible the propagation by cuttings of those plants which can not, at present, be successfully grown from cuttings, but also in bettering the results with those plants which are now propagated in this way.

The marked morphological differences which often exist between one-year-old and older seedlings, may be expressions of just as pronounced nutritional or anatomical differences within the plant which in turn may be responsible for the differences in rooting response. Investigation of such differences is now in progress and it is hoped that some definite information will be gained concerning the internal conditions necessary for the rooting of cuttings.

Some Facts Concerning Soil Moisture of Interest to Horticulturists

By A. H. HENDRICKSON and F. J. VEIHMEYER,
University of California, Davis, Calif.

CONSIDERABLE confusion exists in the manner of reporting the results obtained in soil-moisture determinations in water relations experiments. Furthermore, there is also a lack of clear understanding of some of the principles involved. This paper is intended to discuss some rather fundamental changes in point of view which seem to grow out of our experimental work.

The need for such a brief discussion seems necessary when we frequently hear horticulturists speak of the drought resistance of certain kinds of plants or trees. What is meant by this term? Is one kind actually able to secure more water from the soil, or is it simply able to withstand drougth conditions for a long period and manage to exist in spite of unfavorable soil-moisture conditions? The term "retentive" is also frequently used in describing soils suitable for fruit trees. Retentive of what? Moisture is usually meant, but upon consideration it will be admitted that retention of moisture is hardly a desirable characteristic of soils. Would it not be better to say that the soil contained an ample amount of water, leaving the impression that the water was there to be used by the tree, and not something that it was desirable to have the soil retain? We hear less about conserving moisture by cultivation than formerly, but even that idea still prevails to some extent, in spite of evidence which clearly shows the fallacy of this theory.

Without going into the history of the entire problem concerning the water relations of plants in detail, it is sufficient to recall that Briggs and Shantz in 1912 laid down certain fundamental concepts of the water relations existing between plants and the soils on which they were growing when permanent wilting occurred. Briggs and Shantz found that the percentage of moisture remaining in a given soil when permanent wilting was attained, under various evaporating conditions, was the same for all plants, and that this percentage could be obtained by calculation from the moisture equivalent by dividing by the factor 1.84. Our work has given results in close agreement with the first part of the work given above but not with the second.

We may consider the volume of soil in which most of the roots of the plant or tree are growing as a reservoir containing a potential supply of water. At the beginning of the growing season, the soil is ordinarily filled with water to its field capacity. By field capacity is meant that amount of water held against the force of gravity, drainage being unrestricted. The actual amount of water held in this volume of soil depends on many conditions, among which the most important are depth, kind and uniformity of soil, and distance to water table. The growing plants use water until they wilt, when it is necessary to replenish the supply to keep them turgid. After wilting, the rate of extraction is exceedingly slow. In practice, of course, the soil

should be irrigated shortly before this condition is reached. If the irrigation is applied during the growing season each time before the permanent wilting percentage is actually reached, the soil-moisture curve for the season will show a series of ups and downs corresponding to the application of water by irrigation and its subsequent use by the plants. These use-of-water curves are substantially straight lines, when no decided changes in climatic conditions take place.

For our purpose we have used the term "permanent wilting percentage" to mean that condition of soil moisture at which plants wilt and do not revive when placed in a moist chamber or until water is added to the soil. This condition is the same as described by Briggs and Shantz as permanent wilting. Our permanent wilting percentage is not identical with the wilting coefficient of Briggs and Shantz as will be explained later. Of course, plants may show drooping before they are permanently wilted, but the latter condition is the only one which can be readily ascertained with most plants. The initial drooping occurs only at relatively low soil-moisture contents and usually precedes permanent wilting by a few days.

We believe that the permanent wilting percentage is the important soil-moisture condition and have, therefore, endeavored to use it as a basis for the interpretation of plant and soil-water relations. Formerly, the point at which permanent wilting takes place was calculated by dividing the moisture equivalent by the factor 1.84 according to the formula of Briggs and Shantz. Our work shows, however, that this ratio between the moisture equivalent and the permanent wilting percentage does not hold for all soils. We have found some soils in which this ratio is as low as 1.3 and others where it is as high as 3.8. The variability of these ratios indicates that the amounts of soil moisture relative to the moisture equivalent available in different soils, varies widely, and in turn may decisively influence the irrigation practice on a given soil type, where the moisture equivalent is in close approximation to the field capacity, as has been the case with all but the sandy soils we have used.

Because of the variability in the ratios between the moisture equivalent and the permanent wilting percentage on different soil types, we have not been able to predict the permanent wilting percentage from the moisture equivalent and, therefore, have found it necessary to determine the permanent wilting percentage, directly for each soil studied. In most cases we have also determined the permanent wilting percentage for the sub-soil at various depths as well as for the surface soil. The method of doing this is by growing plants in sealed containers until they permanently wilt, and then ascertaining the residual moisture. This work was done under widely differing evaporating conditions, and the constancy of the permanent wilting percentage is in accord with the findings of Briggs and Shantz. The permanent wilting percentage is determined by the soil and not by the plant nor the evaporating conditions. Our studies up to the present time have not disclosed any indirect method of calculating the permanent wilting percentage.

Growers are concerned with the field capacity and the permanent wilting percentage. The former may only be obtained by adding

water to the soil, and the latter, by allowing the plants to use water until they wilt. Of course the degree of dryness to which the soil is reduced may be controlled by irrigating before the permanent wilting percentage is reached. Our experiments have shown that it is impossible to secure any uniform predetermined soil-moisture condition less than the field capacity, by applying water to the surface of the soil. The permanent wilting percentage is the end point below which plants remove but little water, and the field capacity is the starting point as far as field or pot experiments on water relations are concerned. Our experiments have shown that when a certain amount of water is applied to a volume of soil, that amount of water wets a certain depth of soil to its field capacity, and then downward movement below this depth practically ceases. Our experiments indicate that penetration of moisture under field conditions takes place in about 48 hours after it is applied and that subsequent downward movement is too slow to be of practical importance. To secure further penetration more water must be applied. If an impervious layer is present within the depth of soil wetted, or if there is a decided discontinuity in kind of soil, the results are not necessarily the same as those above. The depth of penetration depends upon the kind of soil and its relative dryness before the water was applied. We have been unable to maintain any desired moisture condition such as 10, 20, or 30 per cent or a theoretical amount such as "optimum" by applying water to the surface. Furthermore, it is doubtful whether any soil watering device for use in containers will maintain such condition for any period long enough to be considered seriously in experimental work.

We believe that in water relations studies, the soil-moisture conditions should be expressed in terms of availability of water, using the permanent wilting percentage as a basis. In this way much confusion brought about by the use of such terms as "lightly irrigated," "heavily irrigated," "kept at optimum," etc., may be avoided.

Our experiments indicate that so long as orchard trees show by the progressive decrease of moisture in the soil from week to week during the growing season, that they are using water at a uniform rate or as fast as evaporating conditions necessitate, neither the growth of the trees nor the growth of the fruit can be altered by the addition of water to the soil. A marked effect on trees and fruit can be seen only when the rate of use shows a decided decrease, indicating that permanent wilting percentage has been nearly reached. The length of time during which the soil remains at or below the permanent wilting percentage is the most important factor affecting the plants. These points were particularly noticeable in some recent experiments with peaches. Weekly measurement of the fruit, showed that there was a distinct decrease in rate of growth a few days after the soil moisture was reduced to the permanent wilting percentage in the upper four feet. On the other hand, no increase in rate of growth was observed with peaches when water was added to plots in which the soil-moisture content was above the permanent wilting percentage.

As a result of our own experiments, as well as those reported by others, we are convinced that the term "drought resistance" as often

used has but little meaning. Drought resistance in a broad sense is the ability of a plant to survive long periods with the soil moisture at or below the permanent wilting percentage, and to resume growth and fruiting when water is again added to the soil, but not to withdraw moisture below the permanent wilting percentage rapidly enough to prevent wilting. The permanent wilting percentage is determined by the soil and apparently is not changed either by the kind of plant, by evaporating conditions under which the plants are grown, or by the number of times the plants were wilted. In our experiments the permanent wilting percentage as determined by growing sunflower plants in sealed containers, closely approximated that observed in peach orchards when the trees wilted.

In our work we have endeavored to emphasize the fact that growing plants either have available soil moisture or they have not, and so long as the soil moisture conditions fluctuate between the field capacity and the permanent wilting percentage by irrigation and subsequent removal by roots of living plants, nothing more can be done by the grower to influence growth or yields by any operation having for its purpose a modification of the water relationships between the plant and soil.

The chief purpose of this paper is to point out the need of greater uniformity in discussing soil-moisture conditions with respect to plant growth. For convenience and accuracy, we believe that soil moisture should be expressed as percentage on an oven dry weight, from which conversion to actual quantity may be calculated if the volume weight of the soil in place is known. The response of the plant, whether expressed as length growth, area of trunk cross-section, yield, or dry matter produced, we believe, should be stated with respect to the number and length of each period that the soil moisture was reduced to the permanent wilting percentage during the growing season of the plants in question.

The Effect of Early Defoliation of Vegetable Plants on Subsequent Growth and Production

By L. R. VAN GRAAN, *Cornell University, Ithaca, N. Y.*

DEFOLIATION or leaf pruning at transplanting time is practiced by vegetable growers in this country and in other countries. It is claimed that leaf pruning decreases the loss of water until the transplanted plants have replaced their roots sufficiently to take care of the transpiration by the leaves, and this brings about better conditions for growth, resulting in early maturity.

The problem has been of considerable interest because there is reason to suppose that the reserve food supply rather than the moisture supply has been the limiting factor for satisfactory increase in yield and earliness. The data presented in this paper are concerned with the effect of defoliation or leaf pruning at transplanting time on subsequent growth and production of the tomato, celery and cabbage.

The experiments were carried on in the gardens and greenhouses of the Department of Vegetable Gardening at Cornell University. In the greenhouse experiments the tomatoes and the cabbage were grown in 2-gallon glazed jars filled with a good screened garden soil. The celery was grown in 1-gallon jars in a culture of quartz sand fertilized with a 5–10–5 commercial fertilizer, 10 grams to each jar. Observations were made on leaf area, transpiration, wilting, root replacement, earliness, and total product.

The treatment given the plants, and the methods of defoliation were, (1) No defoliation, (2) half of leaf surface removed (lightly pruned), (3) three-fourths of leaf surface removed (heavily pruned).

In treatment 2, with cabbage and tomatoes, all the leaves on the plants were cut exactly in half. In pruning the celery plants half of the leaf surface was removed by pinching the leaf blades in half by estimation. In treatment 3, with cabbage, tomatoes, and celery, all leaves were removed except the central crown consisting of two or three leaves.

The tomatoes in the field showed very little difference in foliage between the different treatments after a month. Defoliation brought about neither increased yield nor earliness. Rather was it effective in retarding maturity. The check plants produced a heavier total weight of early fruit. Leaves are necessary for satisfactory yield and early maturity. A small leaf area results in a decreased food manufacturing area. Defoliation, therefore, will not benefit the tomato.

TABLE I—EFFECT OF EARLY DEFOLIATION OF CELERY ON YIELD IN THE FIELD.

Treatment*	Yield in Tons per Acre	Difference in Tons	Per cent Increase	Significance
Check	18.87±0.998	———	——	———
Lightly pruned	19.36±1.969	0.49±0.194	2.5	2.72:1
Heavily pruned	19.84±0.944	0.97±0.177	5.2	32.2:1

*30 Plants in each replication.

With celery planted in the field there was an increase in yield in the treated plants as shown in Table I. Celery is a leafy vegetable plant, hence will be affected in a different way by leaf pruning than the tomato. Unlike the tomato which is a fruit, it makes vegetative growth only. A possible explanation for the increase might be the following. By removing some of the foliage the transpiring surface is decreased and the water supply will be sufficient to keep the remaining leaves functioning for a longer period of time during the day. As a result of this there will be more food manufactured in the process of photosynthesis because of the continuous opening of the stomata. There is no change in the type of growth because both roots and tops are reduced proportionately, resulting in continuous growth. The double check has a sort of balancing effect on the water supply, making for a condition where growth of the plant will not be slowed down to the extent that the growth of unpruned plants will be. The period of stoppage of growth of unpruned plants is of longer duration owing to the larger transpiring surface that has to be cared for by a reduced water supply, and this retards growth. The rate of water supply is low, causing turgor to be lost early in the day and the stomata to close, and with the stomata closed the manufacture of food is interfered with. Carbon dioxide cannot enter the plant and the process of photosynthesis is stopped.

With cabbage in the field there was no increase in total yield in the treated plants but earliness was increased. The percentage of total cut as early was 56.2 for check; 74.3 for lightly pruned; 74.7 for heavily pruned. The average increase in earliness over the unpruned plants was 18 per cent for the treated plants.

In studying the effect of defoliation on root growth in the greenhouse, washings were made at weekly intervals. The results with the tomato showed that root replacement with unpruned plants was much more rapid than with treated plants. Leaves, therefore, are necessary for the development of a good root system in the tomato immediately after transplanting.

Unpruned cabbage plants also had larger root systems and made more top growth than treated plants. The average length of the roots of the unpruned plants was greater than that of the treated plants.

The celery plants grown in the greenhouse in a culture of quartz sand having a moisture content of 12 per cent, gave an increase with heavily pruned plants. The average increase for the check plants was 10.7 grams, for the lightly pruned 10.2 grams; for the heavily pruned 12.9 grams for the five weeks' run. Since the plants used in the experiment were weighed together it was not possible to calculate odds. It is, therefore, questionable whether these results are significant, but they seem to bear out the results obtained in the field.

In order to study the effect of defoliation and wilting *with* transplanting, 15 tomato plants were used; 5 were pruned lightly, 5 were pruned heavily, and 5 were left unpruned. They were then wilted for 24 hours, the roots being covered with cotton and waxed paper to prevent injury from direct drying. After 24 hours' wilting they were planted in 2-gallon glazed jars filled with a good garden soil,

and grown for three months. All the plants survived. Production data taken on the 3 treatments showed that treated plants set and ripened fruit very much earlier, and yielded more. The number and weight of fruits harvested are given in Table II.

*TABLE II—THE EFFECT OF EARLY DEFOLIATING PLUS HEAVY WILTING OF TOMATOES ON SUBSEQUENT GROWTH.

Date Harvested	Yield of Ripe Fruit					
	Number Fruits			Weight in Lbs. and Oz.		
	Check	Light	Heavy	Check	Light	Heavy
Sept. 18	–	9	6	—	2—0	1—0
Sept. 29	1	–	–	0—2	—	—
Oct. 6	2	3	2	0—2	0—6	0—6
Oct. 13	1	–	6	0—4	—	1—4
Oct. 20	3	2	5	0—9	0—3	1—13
Oct. 28	9	7	6	1—10	1—6	1—0
Total	16	21	25	2—11	3—15	5—7
	Yield of Green Fruit					
Oct. 28	43	45	55	4—13	4—2	4—12

*5 plants used in each treatment.

An experiment to study the effect of defoliation on transpiration after transplanting brought out that unrpuned plants transpired more per square inch of leaf surface than treated plants. The transpiration of the unpruned tomato plants for the first ten days was 144.9 per cent of that of lightly pruned plants. The transpiration of the unpruned cabbage plants was 141.4 per cent of that of the lightly pruned plants. The transpiration in grams per square inch of leaf surface for the entire period (1 month) of the experiment is shown in Table III.

SUMMARY AND CONCLUSIONS

Leaf pruning done in the field resulted in a reduction in total yield with the tomato and cabbage, but the odds did not indicate that the difference was significant; with celery it resulted in an increase in total product. The odds of significance were 32:1 in favor of heavily pruned celery plants. Pruning cabbage plants resulted in an increase in earliness of 18 per cent over the check plants.

Results of experiments carried on in the greenhouse indicated that root replacement was more rapid in the case of unpruned plants. Also the root systems of unpruned plants were more extensive. The average length of the roots of unpruned tomato and cabbage plants was greater than that of the pruned plants.

Heavily pruned celery plants increased at a more rapid rate than unpruned plants, the average increase for unpruned plants being 10.7 grams, and for heavily pruned plants 12.9 grams over a period of five weeks.

Results of the experiment of leaf pruning plus wilting with transplanting indicated that with the tomato, pruned plants recover more rapidly than unpruned after transplanting. All plants used in the

TABLE III—TRANSPIRATION AFTER DEFOLIATION AND TRANSPLANTING.

Plant	Treatment	* Initial Wt. of Tops in Grams	Initial Wt. of Roots in Grams	Initial Leaf Area in Sq. Inches	Wt. of Tops at End in Grams	Wt. of Roots at End in Grams	Leaf Area at End in Sq. Inches	Transpiration After 10 Days in Grams	Transpiration After 30 Days in Grams	Transpiration in Grams per Sq. Inch of Leaf Surface
Tomato	Check	136.4	18	324.75	1499.8	128.12	3651.85	7832	45074	12.6
	Light				1243.1	119.9	3330.08	5404	38116	11.4
	Heavy				Suffocated	Suffocated	Suffocated	536	Suffocated	Suffocated
Cabbage	Check	46.5	2.5	130.65	538	24.2	1208.53	1537	13836	11.4
	Light				515.7	19.4	1156.44	1158	12033	10.4
	Heavy				Suffocated	Suffocated	Suffocated	121	Suffocated	Suffocated

*Initial wt. of 3 duplicate plants. All heavily pruned tomato and cabbage plants were suffocated by tenth day. 15 plants of each kind used.

test survived. The transpiration of pruned tomato and cabbage plants was less per square inch of leaf surface compared with unpruned plants.

The writer is aware of the limitations of such a study as this. One year's results are hardly convincing enough in spite of the several replications for each treatment. At least three years' results are necessary before definite conclusions can be drawn. The evidence presented in the studies made would seem to warrant the conclusion that there is no consistent advantage in earliness and yield due to leaf pruning at the time of transplanting.

Although with cabbage there appeared to be a slight advantage in earliness, and with celery in total product, it is questionable as to whether the differences were entirely due to the treatment, and great enough to be of any significance. When a practice is justified the difference must be so great as to compensate the grower for time and money expended.

It seems plausible to believe that leaf pruning at the time of transplanting is not profitable and of no consistent advantage to the plants studied.

Spacing Time-of-Planting and Size-of-Seedling Studies with California Early Red Onion

By H. A. Jones, *University of California, Davis, Calif.*

THE California Early Red onion is grown in limited acreages in the Sacramento, San Joaquin, and Santa Clara Valleys and to some extent in other districts of California. The seed is usually sown in open beds in August or September and the seedlings set in the field sometime during the winter. The crop is usually harvested somewhat immature in late May or June and is shipped before other varieties that have been seeded in the field. It is oblate in shape, light red in color, very mild, a rapid grower, and a heavy yielder; it does not keep well in storage and does not bolt readily. According to Morse (1) it is a selection of Red Italian Tripoli. For profitable production earliness and high yields are necessary.

Spacing Studies

In 1927 spacing tests were started to determine the influence of planting distance on time of maturity, yield, and size of bulb. Lines of onions were used that had been inbred one generation and then group pollinated. The method of inbreeding used was to cover the inflorescences of a mother plant with one-pound manila paper bags. The best bulbs grown from this selfed seed were grouped and open pollinated under isolated conditions to secure a sufficient amount of seed. This method gave much more uniform material than the ordinary commercial stocks. This seed was usually sown sometime in September and the seedlings transplanted to the field in December or January. All plots were given exactly the same treatment except for spacing.

The seedlings were spaced 3, 4, 6, 8, and 12 inches in rows 18 inches apart. In 1927, 1928, and 1929 the plots were 48, 36, and 27 feet long, respectively. The first two years there were three rows to the plot, and the last year two rows. The plots were flanked by guard rows. Water was applied in shallow furrows between the rows. The bulbs were considered to be mature when the tops broke over at the neck. Immediately after the tops fall they start to yellow which indicates that growth has stopped. In every case the plants that were set three inches apart in the row started to ripen first. The figures in Table I show that as the space between plants in the row was increased from 3 to 12 inches there was a delay in the time of maturity, an increase in the size of the bulbs, and a decrease in yield per acre. Plants spaced three inches in the row do not grow too large for the average consumer; besides, they have a small neck which is well closed when ripe.

Size-of-Seedling Studies

In this study large and small seedlings were compared. Selection 21–6 was used in 1927 and 1929, and selection 21–29 in 1928. They were grown in the same manner as those used in the spacing tests. All of the seedlings were started at the same time. At time of trans-

planting the very small ones that would not transplant well were discarded; those remaining were divided equally into two groups of large and small seedlings. In 1927 the plantings were made in duplicate, while in 1928 and 1929 they were made in triplicate. In 1927, 1928, and 1929 the plots were 48, 36, and 27 feet long respectively. Single-row plots were used without guard rows, and the seedlings were spaced 4 inches in rows 18 inches apart. As shown in Table II in every test during the three years the large seedlings produced a higher yield of bulbs and the average size of the bulbs was larger. The data shows that there is very little difference in time of maturity between the large and small seedlings that were transplanted at the same time.

TABLE I—Influence of Different Spacings on Yield, Time of Maturity, and Size of Bulb. Conducted at Davis, California, 1927–1929.
1927, Selection 21–6

No. of Replications	Planting Distance Inches	Per cent of Tops Down on				Av. Wt. per Bulb Pounds	Increase in Size Per cent	Actual Yield in Pounds per Acre
		6–3	6–13	6–22	7–7			
5	3	15	33	75	98	.395	0	45,612
5	4	9	23	64	97	.476	20.5	41,197
5	6	3	13	50	92	.657	66.3	35,774
5	8	2	6	35	85	.717	81.5	30,926
5	12	0	1	28	66	.780	97.5	21,796
1928, Selection 21–24								
		6–9	6–19	7–9	7–19			
3	3	20	57	96	100	.405	0	42,977
3	4	9	42	85	95	.511	26.2	41,650
3	6	7	30	82	94	.666	64.4	37,614
3	8	3	20	69	87	.843	108.1	35,687
3	12	0.6	6	53	75	1.000	147.0	28,020
1929, Selection 21–6								
				6–25	7–1			
5	3	—	—	65	88	.649	0	73,809
5	4	—	—	52	86	.789	21.6	68,619
5	6	—	—	23	57	.990	52.5	57,272
5	8	—	—	6	27	1.152	77.5	52,890
5	12	—	—	5	15	1.276	96.6	38,020

Time-of-Planting Studies

This experiment was combined with that for size-of-seedling; the data collected being from the same material. The seed for a season's work was all sown at one time so there was no difference in the age of the seedlings; the difference was in the date at which they were transplanted. As a rule the seedlings make very little growth above ground during late December and January regardless of whether they are in the seed bed or in the field. The development of the root system, however, is continuous, plants set early during the winter develop a more extensive root system than those set late. At the end of the cold weather in late winter there is very little difference in the growth of the plants above ground that have been

TABLE II—INFLUENCE OF SIZE-OF-SEEDLING AND TIME-OF-PLANTING ON YIELD, TIME OF MATURITY AND SIZE OF BULB. CONDUCTED AT DAVIS, CALIFORNIA, 1927–1929.

Transplanting Date	Size of Seedling	Av. Wt. Trimmed Seedling Grams	Plant Size 3-15-27		Plant Size 4-26-27		Per cent of Tops Down on		Av. Wt. per Bulb in Pounds	Actual Yield per Acre in Pounds
			Diam. in mm.	Ht. in cms.	Diam. in mm.	Ht. in cms.	6-5-27	7-6-27		
1-18-27	Large	1.98	5.4	18.7	16.5	53.5	53	94	.63	53845
1-18-27	Small	1.13	4.0	15.8	13.0	44.2	51	91	.54	44014
1-25-27	Large	1.41	4.9	16.6	14.1	49.8	55	94	.49	50517
1-25-27	Small	.80	3.5	14.7	10.9	41.0	40	85	.43	30250
2-1-27	Large	1.60	4.5	15.3	12.4	47.4	44	92	.57	49761
2-1-27	Small	.92	3.4	13.1	11.2	42.6	44	81	.43	37510
2-18-27	Large	3.02	4.1	11.8	9.5	37.4	29	93	.48	40384
2-18-27	Small	1.33	2.9	9.6	7.3	33.1	32	82	.33	26771
2-22-27	Large	3.01	4.0	10.9	9.0	36.3	34	88	.42	34485
2-22-27	Small	1.20	2.5	8.9	6.9	29.7	17	86	.29	24049
3-1-27	Large	2.45	3.3	7.9	7.1	27.6	13	83	.39	32065
3-1-27	Small	1.05	2.5	6.9	5.8	26.9	10	47	.30	24502
			3-16-28		4-14-28		6-27-28	7-27-28		
1-13-28	Large	2.5	6.3	21.6	12.9	45.7	47	93	.45	38048
1-13-28	Small	1.1	4.4	17.4	10.7	42.2	37	84	.35	28836
1-20-28	Large	2.1	6.7	21.4	12.4	48.9	49	94	.46	38448
1-20-28	Small	.9	4.8	17.3	10.9	43.8	42	86	.32	26700
1-27-28	Large	2.6	6.2	20.9	12.3	46.4	44	91	.47	40718
1-27-28	Small	1.0	4.8	17.5	10.7	43.4	30	78	.32	27101
2-6-28	Large	3.0	5.4	19.5	10.4	37.3	26	70	.41	35244
2-6-28	Small	1.1	3.9	15.1	8.8	35.7	14	72	.28	23363
2-10-28	Large	2.5	5.3	20.5	10.2	37.1	29	79	.42	36179
2-10-28	Small	1.1	3.8	16.7	8.9	37.0	21	74	.32	26834
2-17-28	Large	2.4	4.8	20.1	8.8	34.7	34	89	.32	26300
2-17-28	Small	1.2	3.6	15.4	7.5	31.8	26	86	.29	23229

			4-11-29		5-13-29		6-24-29	7-1-29		
1-9-29	Large	2.6	12.7	52.9	25.5	67.1	45	87	.90	77440
1-9-29	Small	1.5	11.1	31.5	22.0	64.9	59	87	.73	62834
1-16-29	Large	2.5	13.0	50.7	20.5	72.4	45	85	.89	73052
1-16-29	Small	1.5	11.4	48.7	22.9	67.1	58	86	.70	60238
1-23-29	Large	2.8	13.0	47.6	22.5	68.2	54	87	.89	75827
1-23-29	Small	1.6	10.9	43.1	22.6	65.7	43	84	.74	61931
1-30-29	Large	3.1	12.1	48.1	24.1	71.5	41	85	.86	72783
1-30-29	Small	1.7	10.1	41.2	21.1	65.1	32	84	.76	65071
2-6-29	Large	3.3	8.7	36.1	30.9	63.6	20	45	.65	47862
2-6-29	Small	1.8	7.6	33.2	19.3	59.3	18	63	.56	42032
2-13-29	Large	4.6	9.7	35.1	20.7	67.7	16	57	.67	52616
2-13-29	Small	2.0	7.8	33.9	20.7	65.9	18	57	.51	42485
2-20-29	Large	4.9	8.1	32.8	30.9	64.7	14	67	.67	54402
2-20-29	Small	2.0	7.1	32.2	18.0	60.8	21	57	.50	38720
2-27-29	Large	6.8	7.2	29.5	19.9	65.5	15	58	.50	54047
2-27-29	Small	2.8	5.9	25.7	17.7	60.5	13	56	.35	37827

transplanted at different dates, but there is considerable difference in the amount of roots. Consequently those plants transplanted early make a much more rapid growth when warm weather arrives than those planted late, as can be seen from the figures on height and diameter of plant in Table II. The diameter of the plant was measured just above the bulb; height, was measured from the ground level to the tip of the longest leaf. The measurements taken on April 11, 1929 show a marked difference in plants set in the field at different dates. By May 13th there was very little difference in the measurements between the early and late plantings because most of the plants had reached their maximum size in height and diameter of neck; the main difference at this time was in the size of the bulbs.

The plants set early mature somewhat sooner than those transplated late. Also there is a general decrease in yield and in size of bulb. The best yields are obtained when the plants are set early so they will make a good root development during the winter. The plants then develop rapidly with the advent of warm weather and complete their growth before hot weather and thrips become injurious.

Acknowledgments

The author is indebted to T. H. Whitaker, James Millar, and L. H. Phillips for help in carrying out this work.

Literature Cited

1. Morse, Lester L. Field notes on onions. C. C. Morse and Company, San Francisco. 1923.

The Effect of Delayed Pollination on Size of Cob and Kernel in Country Gentleman Sweet Corn

By E. S. Haber, *Iowa State College, Ames, Iowa*

SWEET corn breeding is one of the major projects of the Vegetable Crops Section of the Iowa Agricultural Experiment Station. Inbreeding and crossing of homozygous inbreds has been carried on for five years. The present problem was undertaken as a result of observation of the behavior of the silks when not pollenized at all or by impotent pollen. Workers in corn breeding have noted that the silks remain receptive over a fairly long period of time as compared to the pistils of the flowers of most of our economic crop plants. Pistils or silks of the corn if bagged and not pollenized continue to grow and become exceedingly long.

Weatherwax (3) and other botanists have shown that the pollen tubes usually gain entrance to the silk through the numerous hairs present on the silk. It is not necessary for the pollen grain to gain entrance by falling on the end of the silk. Under favorable conditions it may grow into the silk from any of the hairs along the silk. Probably all parts of the silk down to within an inch or two of the ovary are receptive to pollen. The stigmatic portion is not limited to parts exposed beyond the husk.

The accompanying illustration shows the elongated silks which occur when the egg is not fertilized. The two ears in the center are the same age as the two outside ears. The outside ears were bagged 9 days to prevent pollination and subsequent fertilization. The center ears have been naturally pollenized in the field. According to Weatherwax (3) the growth of the silk usually stops as soon as it has been penetrated by a pollen grain. Miller (2) found the growth of the pollen tube to be very rapid. Under normal conditions they reach the embryo sacs of all the ovules on the ears in 24 hours after pollination. This often means a growth of 6 inches in 24 hours or 1500 times the diameter of the pollen grain.

The length of time the silk remains receptive no doubt depends somewhat on weather conditions. Crozier (1) reports the length of time the silks are receptive to be rather long. Weatherwax (3) states that silks are receptive as soon as they emerge from the husks and remain receptive for two weeks or more if not pollenized.

It occurred to the author that since the silks continued to grow when not pollenized, that delayed pollination might have some effect on the size of the cob and kernels. A good commercial strain of Country Gentleman sweet corn was used the three years of the experiment. Four hundred paper sacks were placed over ears just previous to the appearance of the silk to prevent pollination. The sacks were allowed to remain on the ears 12 days in 1927, and 9 days in 1928 and 1929. The sacks were then removed and silks pollenized naturally by pollen shed from the anthers. The corn plant, as a whole, is protandrous (the stamens come to maturity before the pistil). However, protandry is by no means complete. The shedding of the pollen and the receptivity of the silk in the individual plant

usually overlap. Also all the plants in the field do not reach sexual maturity at the same time so that we find that viable pollen may be shed within a field of the same planting over a fairly long period.

Poorly filled ears are often the result of hand pollination, so natural pollination was employed. The paper sacks were removed while the anthers were still shedding enough pollen to form a normal set of grain on the ears. However, in 1927 the sacks were not removed for 12 days and not enough pollen remained to produce a normal set. Some of the bagged ears were not well filled. Sufficient viable pollen at the end of 9 days in 1928 and 1929 produced nearly all normal well-filled ears.

The bagged ears were harvested October 1 each year with an equal number of check ears normally pollenized and allowed to dry in a corn drying room until cob and kernels were at a constant miosture content. Weights were taken when cob and kernel of both bagged and check ears had reached a moisture content of 13.8 per cent in 1927, 14.4 per cent in 1928, and 14.2 per cent in 1929.

The whole ear, minus the husks, was weighed, then the grain shelled off and the cob weighed. The weight of the grain was calculated as the difference in weight of the ear and the cob. In giving the results, ears covered with paper sacks and pollination delayed will be referred to as the bagged series and those ears which were pollinated at the normal time will be referred to as the check series. For each of the three years *n* is less than 400. A few ears failed to develop after bagging. This is not uncommon since in any strain of corn ears may start to develop and then for various reasons fail to develop. The following data are the results for 1927.

SUMMARY FOR 1927

	Mean	P. E. of Individual Values	P. E. of the Means	C. V.
Check Series n = 300				
Ear	116.34 gms.	±20.52	±1.058	26.5%
Cob	16.99 "	± 2.97	±0.142	26.3%
Bagged Series n = 300				
Ear	109.02 gms.	±20.96	±1.058	28.8%
Cob	21.13 "	± 3.55	±0.192	25.2%

Differences

Ears 7.32±1.50 Check ears larger—significant
Cobs 4.13±0.24 Bagged cobs larger—significant

In 1927, if the pollination was delayed by bagging, we find the cobs significantly heavier since the mean difference in weight is about 16 times greater than the probable error. The total weight of the check ears was larger as shown by the mean difference and its probable error. Since the cob of the check ear was smaller, one might attribute the greater total weight of the ear as due to greater kernel weight. However, as stated before, the sacks should have been re-

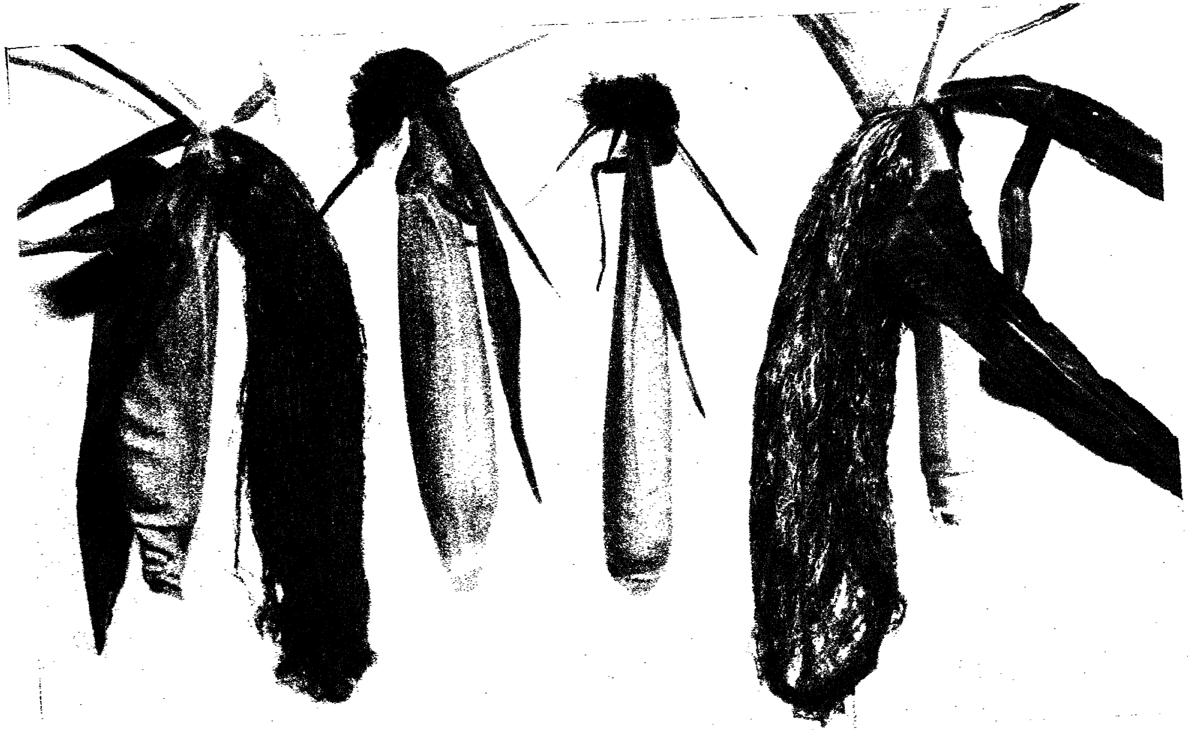


PLATE I—Showing the elongated silks which occur when the egg is not fertilized. The two central ears were pollenized naturally

moved several days previous in order to secure well-filled ears of the bagged series. The heavier total ears in favor of the checks may be due to poorly filled ears of the bagged series.

SUMMARY FOR 1928

	Mean	P. E. of Individual Values	P. E. of the Means	C. V.
Check Series n=350				
Ear	106.55 gms.	±18.46	±1.066	25.9%
Cob	15.59 "	± 2.78	±0.160	26.1%
Grain	90.96 "	±16.43	±0.948	27.1%
Bagged Series n=348				
Ear	106.87 gms.	±13.70	±0.794	19.2%
Cob	19.46 "	± 2.86	±0.165	22.0%
Grain	87.41 "	±11.90	±0.689	20.4%

Differences
- Ears 0.32±1.34 Bagged ears larger but not significant.
- Cobs 3.87±0.23 Bagged larger—significant
- Grain 3.55±1.18 Check larger, just on border of significance

In 1928 we find the whole ear of the bagged series to be heavier but not significantly so, since the probable error of the mean difference is much greater than the mean difference; also the bagged cobs were significantly heavier. The kernels of the check series apparently were heavier just bordering on significance since the mean difference is just about three times its probable error.

SUMMARY FOR 1929

	Mean	P. E. of Individual Values	P. E. of the Means	C. V.
Check Series n=369				
Ear	84.29 gms.	±19.66	±1.023	35.0%
Cob	13.41 "	± 3.09	±0.160	34.6%
Grain	70.88 "	±16.45	±0.856	34.8%
Bagged Series n=351				
Ear	87.59 gms.	±15.72	±0.839	26.9%
Cob	16.30 "	± 2.92	±0.155	26.8%
Grain	71.30 "	±16.45	±0.730	28.8%

Differences
- Ears 3.30±1.34 Bagged larger—significant
- Cobs 2.99±0.23 Bagged larger—significant
- Grain 0.42±1.14 Bagged larger but not significant

In 1929 the whole ear, cob, and kernels in the bagged series were heavier than the check series, though kernel weight was not significantly larger.

Since the shelled corn from each individual ear in both bagged and check series had been saved separately for both 1928 and 1929,

the author decided to weigh a random sample of 20 kernels from each ear to see if pronounced consistent differences in kernel weight could be noted. Since the kernels had been saved in numbered envelopes, 20 kernels taken at random from every fifth envelope were counted out by a disinterested person. These were weighed on a chemical balance.

SUMMARY OF KERNEL WEIGHTS

1928 n=75	Mean	P. E. of Individual Values	P. E. of the Means
Check Series	2.5373 gms.	±0.2716	±0.0314
Bagged Series	2.7284 "	±0.2270	±0.0264
1929 n=92			
Check Series	2.1804 gms.	±0.3306	±0.0344
Bagged Series	2.2069 "	±0.2458	±0.0264

1928 difference
0.1911±0.0415 gms. Bagged significantly larger.
1929 difference
0.0265±0.04390 gms. Bagged larger but not significant.

Kernels in the bagged series were significantly larger in 1928 since the mean difference is more than four times its probable error. This is not in accord with the grain weight as given in the summary for 1928 where the check series showed the largest grain weight. Perhaps the ears were not as well filled, although they appeared to be so. Kernels on a poorly filled ear have more room to expand and more food to utilize and usually are larger. Individual kernels in the bagged series for 1929 were larger but not significantly so, which is in accord with results for the total grain weight as shown under the summary for 1929.

No doubt it would have been much better to have used a first generation hybrid than to have used a commercial strain since development of the floral parts and all other parts of the plant are much more uniform in the hybrid. As shown in the summaries of the results of the three years, the probable error of the individual values are large. In all cases they were less than one-third of the mean but no doubt in a good first generation hybrid of inbred strains the probable error would be much smaller. The author did not have any first generation hybrid seed in 1927 when the problem was started but for 1930 a large enough quantity is on hand to make further studies on this and the length of time of the receptivity of the silk.

In conclusion, there is no doubt from the results secured, that an increase in weight of cob results from delayed pollination. As to the effect of delayed pollination on size of kernel, it is questionable, although indications are that the kernel may attain slightly greater weight. Since the P. E. is larger than the M. D., the differences are insignificant.

LITERATURE CITED

1. CROZIER, A. A. Silk seeking pollen. Bot. Gaz., 13:242. 1888.
2. MILLER, EDWIN C. Development of the pistillate spikelet and fertilization in Zea Mays. Jour. Agr. Res., 18:255–266. 1919.
3. WEATHERWAX, PAUL. The story of the maize plant. Univ. Chicago Press. 1923.

The First Year's Work Upon Standards and Descriptions of American Varieties of Vegetables

By VICTOR R. BOSWELL, *Bureau of Plant Industry, Washington, D. C.*

A LITTLE over a year ago funds became available to the Office of Horticultural Crops and Diseases in the Bureau of Plant Industry for work upon the standardizing and describing of American varieties of vegetables. In the beginning, considerable time was spent in conferences with Bureau officials, with representatives of the canning and vegetable growing industries and of the seed trade, and with State experiment station workers, in an effort to determine the greatest need of the industry, and what type of program is likely to be most productive of results. Throughout the development of this work, emphasis has been placed upon the importance of close contact with the industry since the work is being taken up in response to the demands of the industry and is being designed as a service to it. The results will be useless, or at least largely ignored, if they do not meet the requirements of those agencies it is designed to benefit. From the first, numerous workers all over the country have indicated a desire to assist in this large project. Unfortunately, it has not been possible to expand activities so as to co-operate with all of those who are interested but an attempt has been made to establish investigations over as wide a range of conditions as possible with the available resources.

Just a year ago during the meetings of this society in New York, a group of Bureau and State experiment station men co-operated in the completion of details of procedure for the first year's effort, realizing that experience would doubtless show need for subsequent changes.

The present object of this project is to find and adequately describe the existing type of each of the important commercial varieties of certain crops which most nearly conforms to the generally accepted ideal for that variety. In selecting a type to be described and set up as a standard, the best opinions among technical workers, canners, seedsmen, and growers are to be considered. This point is re-emphasized since it is obvious that any arbitrary establishment of a standard which will not be acceptable to the industry will be of no value. Activities will be confined for the present at least to the more important commercial varieties. It is believed that an effort to include all listed varieties of any one crop, although desirable, would be such a huge task as to seriously limit the number of crops that could be handled and would also greatly delay the completion of the work upon any one crop. The greatest demand from the industry seems to be for as prompt establishment of adequate standards and descriptions of the important varieties as possible, rather than for descriptions of all existing varieties and synonyms.

Each stock is to be grown under each of several widely different sets of conditions over a period of three years, at the end of which time it is believed that a definite choice of a standard and an adequate description of it can be established. Most varietal descriptions

in the past have been based largely on comparisons and points of difference between varieties. Descriptions of this sort are of comparatively little value to the layman because he is not familiar with the varieties used as a basis for description and comparison. It is believed that if differences actually exist between supposedly different varieties each can be described in terms of size, shape, color, time of maturity, etc., these terms to be referred to commonly known standards so that the description will be intelligible to those who are not widely familiar with varieties. An important feature of this descriptive work is the use of adequate photographs, drawings, and illustrations in natural colors.

In this first year's work a small list of the most important varieties of tomatoes, cabbage, and peas was studied. These lists were decided upon after consulting representatives of the various phases of the industry in regard to the importance of the varieties being grown. An effort was made to select those varieties constituting 80 to 85 percent or more of the seed handled. There is little question but that a relatively few varieties constitute perhaps 90 percent of the commercial acreage of any one crop. The varieties follow: *Tomatoes:* Earliana, Bonny Best, Marglobe, Globe, Greater Baltimore and Stone. *Cabbage:* Early Jersey Wakefield, Copenhagen Market, All Seasons, Late Flat Dutch, Wisconsin Hollander and Danish Ballhead. *Peas:* Alaska, Surprise, Admiral, Green Admiral, Advancer, Perfection, Premium Gem, Nott's Excelsior, Sutton's Excelsior, Laxtónian, Little Marvel, Laxton's Progress, Daisy, Gradus, Thomas Laxton, Hundred-fold, World's Record, Telephone and Alderman.

This much longer list of peas was grown since work on this crop has been under way for some time and but little more data are needed to publish a report on these varieties. It is planned to study additional varieties of tomatoes and cabbage next year and subsequently.

Numerous stocks of each of the varieties listed above were secured through the aid of the Vegetable Research Committee of the American Seed Trade Association, the members of which are familiar with the original sources of seed of these crops. By going to the original sources, the growers who produce these varieties, instead of ordering very extensively from dealers who are not producers, a large amount of duplication of stocks has been avoided, and at the same time it is felt that most of the better stocks have been secured. Sufficient seed has been secured to supply all collaborators for a period of three years. The sources of all stocks are kept entirely confidential in order to eliminate possible prejudice in making decisions, and to avoid any possible unfair discrimination in favor of or against private enterprise.

All details of plot technique such as planting distances, sizes and arrangements of plots, and methods of growing plants as well as the securing of all data have been executed according to a uniform, prearranged plan. All photographs have been taken to the same scale and in most cases with the same character of photographic materials. The measurements to be used as a basis for description have been worked up in a uniform manner and the season's results have been

worked over and discussed by the entire group in conference. It is planned to hold at the end of each year's work, regional conferences in which a group of workers upon a particular crop shall gather for the purpose of working over and discussing each season's results and planning the next season's work. During the growing season the various collaborators have had an opportunity to visit the plots of certain other collaborators so as to learn how the various stocks behave under conditions different from their own.

Investigations were in progress during the season of 1929 upon the three crops named at Arlington Farm, Virginia, and also in charge of the collaborators listed below. The crop studied by each is indicated.

CABBAGE

H. H. Zimmerley—Va. Truck Expt. Sta., Norfolk, Va.
R. A. McGinty—S. C. Agr. Expt. Sta., Clemson College, S. C.
J. E. Knott and C. E. Myers—Pa. Agr. Expt. Sta., State College, Pa.
J. C. Walker—Wis. Agr. Expt. Sta., Maidson, Wis. (plots near Racine)
W. C. Edmundson—Colo. Potato Agr. Expt. Sta., Greeley, Colo.
V. R. Boswell—U. S. D. A. (Plots at Arlg. Farm, Va.)

TOMATO

Paul Work—Agr. Expt. Sta., Cornell Univ., Ithaca, N. Y.
G. E. Starr—Mich. Agr. Expt. Sta., East Lansing, Mich.
H. D. Brown—Purdue Agr. Expt. Sta., Lafayette, Ind.
V. R. Boswell—U. S. D. A. (Plots at Arlg. Farm, Va.)

PEAS

E. J. Delwiche—Wis. Agr. Expt. Sta., Green Bay, Wis. (Plots near Sturgeon Bay.)

D. N. Shoemaker—U. S. D. A. (Plots at Arlg. Farm, Va.)

Co-operative relationships have been established also with O. H. Pearson, California Agricultural Experiment Station, Davis, California, and H. P. Traub, Texas Agricultural Experiment Station, College Station, Texas. Arrangements were completed too late to carry on work in 1929, but they will work on both tomatoes and cabbage in the future.

This past season the collection of data upon peas was completed with the exception of illustrations of foliage. Unusually early, hot, dry weather damaged the foliage at the Arlington plots; an aphis attack at Green Bay, Wisconsin, rendered the value of foliage illustrations questionable, but excellent pod illustrations were completed. For the most part, normal growth of early cabbage was secured, together with satisfactory data, but the very general and severe late summer drought seriously damaged the crops at Racine, Wisconsin, and at Arlington Farm, Virginia. At State College, Pennsylvania, fair results were secured. Good results were secured at Greeley,

Colorado, under irrigation. Although the tomato crop was cut somewhat short by dry weather, the data secured by all workers are acceptable.

In the beginning of this program the objection was raised that individual workers in different parts of the country would so differ in their ideas concerning the excellence of certain strains that there could be no agreement nor conclusions reached in the matter of recommending an ideal type. The past year's experience has indicated that this objection is not nearly so serious as might be supposed. It is interesting to note that in many cases the same strain of any given variety was chosen as the ideal by all the workers. Where there was a difference of opinion about the strain to be selected it was usually found that the differences of opinion were very slight and that the two or more strains over which there was disagreement were really quite similar. There were only two cases, however, in which this general agreement did not hold. These differences of opinion are typical of what may arise in the course of this work but there is little doubt that practically unanimous agreements can be reached which will insure the acceptance of a standard. The surprising thing has been that there has been so little disagreement.

It would be unfair to say that the stocks in general which the trade sent in response to our call for their best were disappointing but it is true that an appreciable number of them showed a far greater variability and deviation from what is considered good type, than had been expected.

December 19 and 20, the entire group of collaborators met in Washington to discuss the year's results and make recommendations for the coming season. It is of course too early to make recommendations concerning the ideal or standard for any variety but agreement has been reached tentatively on the first year's work. These tentative conclusions are, of course, subject to change. It is planned to drop certain of the least desirable stocks of different varieties in order to eliminate unproductive effort; to increase the size of the plantings of the desirable strains to furnish a larger mass of material which will be desirable for description. With accumulated experience and the elimination of some of the less desirable strains it will be possible to increase the list of varieties. This coming year it is planned to add the following: *Cabbage:* Winnigstadt, Glory of Enkhuizen. *Tomato:* Santa Clara Canner, Gulf State Market, Early Detroit.

One of the most difficult readings to make in varietal studies is that of color. The few color standards available in this country are rather expensive to purchase and they consist of such a small number of tints and shades of the various hues that wide gaps exist between them. It is a frequent experience that when one attempts to match a certain color of leaf or fruit, the existing color is found to be quite different from any represented in the standard. A series of spectrum hues, giving a total of approximately 5,000 tints and shades, has been planned. It is believed that such a series of color values will adequately meet the requirements of this work.

A few individuals have expressed a skepticism concerning the advisability of attempting to work out the standardization and description problem upon a co-operative basis as is being done, but representatives of the Bureau are glad of this opportunity to acknowledge with appreciation the very satisfactory and perfectly fine relationships which have been present throughout the planning and initiation of this work. It is only regretted that more neighbors in the States cannot at this time be included in the program because of limited resources. It is hoped that as the work expands, more and more will be able to work into the project until the country is adequately covered by an extensive series of varietal studies, all carried on under a uniform and unified plan.

A Systematic Study of the Peppers (*Capsicum frutescens*, L.)

By A. T. Erwin, *Iowa State College, Ames, Iowa*

THE peppers, though one of the minor groups of vegetables from an economic standpoint, are of unusual interest for a systematic study, first, because of the multifarious forms represented, and, second, because they are one of the few vegetables of which the native type still abounds, thus affording opportunity to trace definitely the changes which have taken place at the hands of the plant breeder.

Generally speaking the field of systematic studies of vegetable crops has been but meagerly covered and does not compare either in quality or quantity with the work done in the corresponding phases of pomology, as any one who has attempted to organize the literature for a course in systematic clericulture will testify. The excellent work now being directed by Dr. Victor R. Boswell of the United States Department of Agriculture, and also the projected series of the New York Agricultural Experiment Station, will prove important contributions to this field.

Primitive forms of the Capsicums are common in Mexico and South America, and, while the plant has become naturalized in many tropical countries the fact is pretty definitely established that its native home is in the regions just named. Further light upon its nativity is evidenced by the fact that pepper seed was found by Safford in the mortuary bowls of the prehistoric cemetery of Anicon, near Lima, Peru, and Bancroft (1) records the fact that it was a food plant of the Olmecs, a Mexican tribe preceding the Toltec culture.

The nomenclature of this genus is delightfully confused, both botanically and horticulturally speaking. Linnaeus described two species of Capsicums, *C. annuum* and *C. frutescens.* Fingerhut added another 25, and the list has been added to at one time and another until a total of something like 100 supposedly species of Capsicums have been described. Irish (2) in his "Revision of the Genus Capsicum with Especial Reference to Garden Varieties" recognized two species, *C. annuum* and *C. frutescens.* Bailey (3), who has for years given special attention to both the native and cultivated forms of this genus, expresses the opinion "That the horticultural kinds are all forms of one species, and that the species is shrubby, the herbaceous or so-called annual kinds being races that develop in a short season and do not become woody before killed by frost. In the Capsicum shrubs of the tropics one finds puffy fruits of the bell-pepper type as well as the slender finger-like and the berry-like kinds; and when the northern kinds are grown in the tropics they become shrubs. Leaf variation also has equal range. I therefore propose to arrange the most significant forms of this multifarious species under *C. frutescens* rather than under *C. annuum.* In doing so, I accept the second rather than the first of the two names proposed by Linnaeus in *Species Plantarum;* but when no question of authority or priority is involved, I cannot allow the accident of precedence on pages to obscure a biological fact."

It will be noted that one important differentiation between *C. annuum* and *C. frutescens* is that the one was supposed to be an herbacious annual and the other fruitescent or woody and hence a perennial. The fallacy of this distinction is readily proved by lifting any of the garden varieties before frost, cutting them back and removing them to the greenhouse. This I have done repeatedly and the plants will continue to grow for an indefinite period providing they have not become exhausted before being lifted. In other words as suggested by Professor Bailey they are made an annual due to the life of the plants being cut short by killing frosts.

For the past two years we have carried on our station grounds a complete collection of practically all the varieties offered in the American seed trade. From the studies of this collection made by the writer and an examination of the excellent collection of native forms found in the Field Museum of Natural History, which the author was privileged to examine, we are convinced of the correctness of Dr. Bailey's interpretation, and in this paper all of the varieties of Capsicums are classed as forms of *C. frutescens*. We may add further that Professor Irish states that he is now convinced that the cultivated peppers all belong to one species of Capsicum.

The nomenclature of the garden varieties is equally confused. In some of the trade catalogs, for example, the term "Pimento" is used to designate a variety with an oblate form of fruit, such as the tomato pepper. Others list as a Pimento pepper a conical-shaped fruit, which in reality belongs to an entirely different group from the Pimento. The multiplicity of varietal names and the introduction of synonyms has placed an unnecessary burden on the public. A variety as a distinct entity has lost its significance in a good many instances, and we are coming to think of these various cultigens more and more in terms of their type or group relationship.

The numerous cultivated forms of peppers are rather difficult to delimit. Various characters have been proposed as a basis for classification, but in the studies made by the author the one taxonomie character which seems to hold consistently throughout is the typc of calyx. There are two distinct types of calyx found, the one being pateraform or saucer shaped and the other cup shaped. The erect or pendent habit of fruiting has also been used and this holds in certain groups such as the Chili. On the other hand, in others as the Cayennes, this character is variable, and sometimes on the same plant you will find both erect and pendent fruits.

Since the principal use of the cultivated peppers is as a condiment, it therefore seems logical from a horticultural standpoint to divide the varieties into two general classes, namely, the pungent or hot peppers and the non-pungent or sweet. In making this classification it is recognized that the terms "pungent" and "non-pungent" are relative, as the percentage of capsaicin varies widely in the different groups. We have some varieties with a thick flesh which in general characters are clearly sweet peppers and yet are not as mild as other groups. Hot strains also appear at times in certain varieties of sweet pepper to annoy and perplex the seedsmen.

The following list shows the various groups of non-pungent or sweet peppers and the varieties belonging to each group, and likewise the pungent or hot varieties.

CONSPECTUS OF CULTIVATED TYPES OF CAPSICUMS

I. Pungent or Hot Peppers
  A. Calyx cup shaped, embracing base of fruit.
    1. Fruit short, usually under 2 inches long, erect.

CHILI GROUP

    2. Fruit usually over 2 inches long, curved, commonly pendent. Fruits distinctly larger than preceding.

CAYENNE GROUP

  B. Calyx saucer shaped, not embracing base of fruit.
    1. Fruit globose.

CHERRY GROUP

    2. Fruit conical.

CELESTIAL GROUP

II. Non-pungent or Sweet Peppers
  A. Calyx saucer shaped, not embracing base of fruit which usually forms a concavity.
    1. Fruit broader than long, distinctly oblate.

TOMATO GROUP

    2. Fruit large, scarcely longer than broad, variously ridged and furrowed.
      a. Fruit red—BELL GROUP
      b. Fruit yellow—GOLDEN QUEEN GROUP
    3. Fruit distinctly longer than broad—a long pointed type of sweet pepper.

SWEET SALAD GROUP

Pungent or Hot Peppers	Chili Group	Chili Red	Small Chili
		Tobasco	Japanese Cluster
		Coral Gem	Cardinal
		Chili Dwarf	Orange Red Cluster
	Cayenne Group	Long Red Cayenne	Hungarian Long Wax
		Red Hot	Hot Sicilian
		Hungarian Wax	Half Long Hot
		Heifer Horn	Thick Long Red
		Giant Cayenne	Anaheim
		Mexican Chili	Long Sweet Cayenne
	Celestial Group	Celestial	Little Gem
		Coral Gem	Floral Gem
		Spanish Gem	Prince of Wales
	Cherry Group	Cherry	Yellow Cherry
		Bird's Eye	Creole
		Red Cherry	Chili Piquin

Non-pungent or Sweet Peppers	Bell Group	Bull Nose	Bell
		Ohio Crimson	Early Giant
		Royal King	Great West
		Magum Dulce	Sweet Mountain
		Chinese Giant	California Wonder
		Ruby King	Wonder Bell
		Ruby Giant	Crimson Giant
		World Beater	Prize Taker
	Golden Queen Group	Golden Giant	Golden Queen
		Golden Dawn	Prolific Yellow
		Oshkosh	Golden Hercules
		Golden Bell	Golden Prize
	Sweet Salad Group	Perfection	Sweet Salad
		Rainbow	Salad
		Sweet Meat Glory	Harris Earliest
		Spanish Pimento	Panama
		(Giant Pimento	Upright Sweet Salad
		Prolific Red	
		Hamilton Market	
		Neapolitan	
	(Tomato Group	Tomato Shaped	Early Sweet
		Tomato Nain Hatif	Red Apple
		Cheese Pepper	Topepo
		Tomato Salad	Squash
		Sunny Brook	Pickling

Literature Cited

1. Bancroft, H. H. Native Races. 2:343. 1882.
2. Irish, H. C. Revision of the genus capsicum with especial reference to garden varieties. Mo. Bot. Gard. 9th Rpt. 53–110. 1898.
3. Bailey, L. H. Capsicum. Gentes Herbarum, Vol. I, Fasc. III, 128–129. 1923.

A Study of Plant Food Deficiencies in Tomatoes for the Canning Factory*

By J. H. MacGillivray[1], G. J. Raleigh, H. Thut, and F. Von-Ohlen, *Purdue University, Lafayette, Ind.*

TOMATO fields have received a great variety of fertilizer treatment. Fertilizer experiments have been an aid to proper fertilization of tomato fields, but these results have been strictly applicable only to the field used. It is evident that there is need for a method (2) of determining mineral deficiencies of tomato fields which is cheap and which will give quick qualitative indications. This problem has prompted a tomato nutrition survey by means of microchemical tests of plants for nitrates, phosphorus, and potassium during the summers of 1927, 1928, and 1929.

Microchemical Methods

Nitrates: 1 gram of diphenylamine was dissolved in enough sulfuric acid (Sp. Gr. 1.84) to make 100 cc. of the reagent which is extremely sensitive. The concentrated acid was used, but it has a tendency to disintegrate the tissue slightly.

For all tests cross sections of the petiole of the third leaf from the growing point were used. The sections were placed on a clean glass slide and a drop of the reagent applied to each by means of a dropper. If nitrates are present the blue color becomes established in several minutes, and then breaks down to a brown color. The colors indicated in Table I were used to rate the lack or abundance of nitrates in tomato plants.

Phosphorus: The reagent used was made by adding 1 gram of ammonium molybdate to 12 cc. of nitric acid (Sp. Gr. 1.42). After thorough stirring the solution was allowed to stand until it was possible to decant the clear liquid. All sections were cut free hand as thin as possible with a razor, placed in a small glass dish, and covered with the clear reagent. After 30 minutes the reagent was poured off and the sections were washed for 5 minutes in a 1 per cent solution of hydrochloric acid. The acid was poured off and a 1 per cent solution of phenylhydrazine hydrochloride added. The sections were always allowed to remain for 15 minutes in the phenyhydrazine hydrochloride solution before the results were recorded. The appearance of a bluish green color indicated the presence of phosphorus. The amount of phosphorus was rated according to the colors in Table I.

The ammonium molybdate reagent must be used fresh because after several hours the ammonium molybdate inactivates the nitric acid. Always the reagent used had been made within an hour. The phenylhydrazine hydrochloride was made up fresh each week. The Spurway (1, 3) test was used in 1927.

*The survey was conducted with funds furnished by N. V. Potash Export My. of Amsterdam, Holland. The authors wish to express appreciation for assistance and criticism of Dr. G. N. Hoffer.

[1]This statement of the work has been prepared by the senior author.

Potassium: The platinum chloride test was used for potassium. This test was used because of the large golden yellow potassium platinum chloride crystals whose identification and abundance are easily determined by the aid of a microscope.

TABLE I—INDICES USED IN RATING PLANT NUTRIENT ABUNDANCE

Rating For Amount of Nutrient	Color According to Ridgway*		Abundance of Potassium Chloro-platinate Crystals in Section
	Nitrates	Phosphorus	
None 0	No change in color	No change in color	0
Slight 1	Pale glaucous blue	Lumiere blue	1–10
Small 2	Porcelain blue	Squill blue	11–35
Medium 3	Blackish green blue	Dusky green blue	36–75
Large 4	Hortense blue	Invisible green	76

*Ridgeway, Robert. Color Standards and Color Nomenclature. Published by author, Washington, D. C. (1912).

The thin cross sections of the petiole were placed in vials containing a 10 per cent solution of platinum chloride in water and allowed to remain two days before examination. The sections then were placed on a glass slide, held in place by a cover glass, dehydrated for 30 minutes with 95 per cent alcohol, and examined. The relative abundance of potassium platinum chloride crystals was recorded according to Table I.

TESTS IN QUARTZ SAND

Indiana Baltimore plants were transplanted June first to pure quartz sand, and grown until July eighth without the addition of plant nutrients, being watered with city water. At this time the plants were of a yellowish green color and showed the effects of starvation. On July eighth the plants were tested, with the results shown in Table II. The pots were divided into four lots and given nutrient treatments as follows: (1) deficient in nitrogen, (2) deficient in phosphorus, (3) deficient in potassium, and (4) complete nutrient solution. The results of Table II indicate that the microchemical tests are accurate. The plants receiving a complete nutrient solution gave a satisfactory rating for good growth except for nitrogen which should be nearer to 3 or 4.

TABLE II—PLANT NUTRIENT RATINGS OF TOMATO PLANTS UNDER DIFFERENT NUTRIENT CONDITIONS.

Nutrient Solution	Lacking Nitrogen			Lacking Phosphorus			Lacking Potassium			Complete		
Elements of Nutrient Rating	N	P	K	N	P	K	N	P	K	N	P	K
July 8*........	0	1	0	0	1	0	0	1	0	0	1	0
July 12........	0	3	1	4	1	1	4	3	0	4	3	1
July 20........	0	4	4	4	0	4	4	3	0	4	3	3
August 16.....	0	4	4	3	0	4	3	3	0	2	3	3

*Tomato plants transplanted to pure quartz sand when two months old, grown for 38 days in sand without nutrients, and then the indicated treatments begun on July 9th.

Work During the Season of 1927

By means of microchemical tests, it was hoped to be able to learn the prominent deficiencies of the different regions of the state and to make recommendations on this basis. This object was not accomplished as fields of high and of low fertility were found in all sections of the state. In many individual fields fertility varied greatly in the various portions of the same field. The problem involved was to study nutrient conditions and the affect of fertilizers so that the different parts of entire fields could be given correct fertilization.

Work During the Season of 1928

The field work consisted of locating fields in various parts of the state which were deficient in one or more elements, and in attempting a correction of this condition by the addition of fertilizer to plots of twenty plants. The fertilizer was cultivated into the soil, suitable checks chosen, and the plots visited every two weeks. It was possible to obtain only the increase or decrease in the number of fruit and not their actual weight. Some fields gave small increases or even slight decreases because the farmers failed to control the weeds, or because of the occurrence of drouth and disease.

A total of twenty-five fields were studied. The nitrate test was found very satisfactory, confirming the results of 1927. Many of the plants which were almost entirely defoliated gave a high nitrate test in the fall. If nitrates have not been used in the production of proteins it requires little to be absorbed from the soil to give a nitrate test in the plant. The phosphorus and potassium tests worked satisfactorily, but they needed further differentiation into classes.

In the twenty-five fields studied the average increase in the number of fruits for the plants fertilized with a complete fertilizer was 36.4 per cent.

Work During Season of 1929

The outline for the work during 1929 was similar to that performed during 1928 except that plots of 10 plants were used and treatments consisted of complete fertilizer or fertilizer lacking one of the three elements.

The results shown in Table III are similar to those of 1928, and consist of the first nine fields and not a selected group. These results seem to show a consistent increase in the number of fruits from fertilizer applications. The tests indicate a remarkably low supply of nitrates even in many of the fertilized plots, at the end of the season. Plant Nutrient Ratings of 2 to 0 are too frequent.

The gains and losses for the fertility tests are summarized in Table IV. The general results show that supplementary fertilization has increased the test rating over the check plots in the cases of all three elements considered.

The nitrates gave the highest test at the beginning of the experiment, and also gave the lowest at the end. This test varied considerably throughout the season. The plants fertilized with nitrogen sometimes did not give a test for nitrates, but they did not

Field Number	Pounds of Fertilizer Applied per Acre by Farmer	Soil Type	Pounds of Fertilizer Applied per Acre Between July 29 to Aug. 13	Plant Nutrient Rating*									Number of Days Between Applying Fertilizer and Last Test	Percentage Increase or Decrease	
				Nitrates			Phosphorus			Potassium					
				First Visit	Last Visit	Net Change	First Visit	Last Visit	Net Change	First Visit	Last Visit	Net Change		Fruit Clusters	Fruits
1	1000 2–12–6	Brn. Silt Loam	300 2–12–6 None	3 3	1 1	—2 —2	1 1	2 2	1 1	2 2	4 3	2 1	42	30	8
2	250 3–18–9	Brn. Silt Loam	300 2–12–6 None	2 2	2 1	0 —1	1 1	2 1	1 0	2 2	3 2	1 0	43	20	15
3	250 3–18–9	Light Clay Loam	150 A. P. (B) 150 $NaNO_3$ (A) None	4 4	1 0	—3 —4	2 2	2 3	0 1	3 3	3 3	0 0	44	51	14
4	300 2–12–6	Light Clay Loam	150 A. P. 150 Potash (C) None	4 4	0 0	—4 —4	3 3	3 2	0 —1	2 2	2 0	0 —2	43	146	2
5	300 2–12–6	Light Clay Loam	300 2–12–6 None	4 4	0 0	—4 —4	2 2	2 1	0 —1	2 2	2 1	0 —1	43	48	5
6	300 2–12–6	Brn. Silt Loam	300 2–12–6 None	4 4	1 0	—3 —4	2 2	1 0	—1 —2	1 1	4 3	3 2	42	60	62
7	300 2–12–6	Brn. Clay Loam	150 A. P. 150 Potash None	4 4	0 0	—4 —4	3 3	4 4	1 1	0 0	4 2	4 2	42	13	—2
8	330 2–12–6	Light Clay Loam	300 2–12–6 300 $NaNO_3$ 150 A. P. None	3 3	4 1	1 —2	1 1	3 1	2 0	1 1	3 1	2 0	42	170	128
9	None	Sndy. Clay Loam	300 2–12–6 150 $NaNO_3$ None	2 2	2 0	0 —2	1 1	2 0	1 —1	1 1	3 1	2 0	29	77	110

*1 indicates low level of plant nutrients. 5 indicates high level of plant nutrients. A Sodium nitrate (15.6% nitrogen). B Acid phosphate (20% phosphoric acid). C Muriate of potash (50% potash).

show as great visible effects of nitrogen starvation as the check row. The nitrate test will indicate the absence of nitrates before the foliage acquires a yellowish green color which is usually correlated with nitrogen starvation. As a whole the plants that received nitrates had much better foliage throughout the summer and appeared to have less leaf diseases.

The plots gave only a fair test for phosphorus at the beginning of the experiment. At the close of the work the test rows had increased nearly one point in the amount of phosphorus while the check decreased .4 of a point. This decrease was probably due to the fact that the translocation of phosphorus to the fruits was greater than the amount the roots obtained from the soil.

TABLE IV—SUMMARY OF ALL FIELDS TO WHICH SUPPLEMENTARY FERTILIZER APPLICATIONS WERE MADE, SHOWING NET CHANGE IN PLANT NURTIENT RATING OF PLANTS, 1929

Fertilizer Applied	None	Nitrogen	None	Phosphcrus	None	Potassium
Test number before fertilizer applied	3.0	3.0	1.7	1.7	1.4	1.4
Test number middle September	.6	1.7	1.3	2.6	1.8	3.0
Net change	—2.4	—1.3	— .4	.9	.4	1.6
Number of Plots		17		19		17

Potassium gave the greatest increase of all. Even the check rows increased .4 of a point. This increase may be due to the roots getting down into the subsoil where they were able to get more potash than in the surface layer.

SUMMARY

The survey of nutritional conditions of canning factory tomatoes made by means of microchemical tests during the summers of 1927–1929 has emphasized two outstanding points (1) the great variation in fertility found in fields of the same region and even different regions of the same field, and (2) the apparent low nutrient level of tomato plants during August and September in one or two of the nutrient elements. There seems to be need of developing a fertilizer practice which will provide the plant with an ample supply of mineral salts during August and September so the plant may make continuous growth, thus insuring the production of high yields on all portions of the same field.

LITERATURE CITED

1. BRAY, R. H. A field test for available phosphorus in soils. Ill. Agr. Exp. Sta. Bul. 337. 1929.
2. HOFFER, G. N. Testing corn stalks chemically to aid in determining their plant food needs. Purdue Uni. Agr. Exp. Sta. Bul. 298. 1926.
3. SPURWAY, C. H. A test for water-soluble phosphorus. Mich. Agr. Exp. Sta. Tech. Bul. 191. 1929.

Studies of Tomato Quality. V Clearing is not Essential in Determining Reducing Sugars of Ripe Tomato Fruit Extract

By J. H. MacGillivray, *Purdue University, Lafayette, Ind., and* A. H. Watson, *University of New Hampshire, Durham, N. H.*

SUGAR determinations on plant extracts usually necessitate the clearing of the solutions. Data obtained on tomato fruit extract indicate clearing is of doubtful value, and may be omitted without any significant effect on the results.

Ripe tomatoes were used in these experiments and the preserved samples were stored in a final concentration of 80 per cent alcohol. Samples 3 to 6 were extracted by the method of Kraus and Kraybill (1). Samples A to C were extracted in a Soxhlet apparatus. An aliquot of each extract was cleared with neutral lead acetate, made up of volume, filtered, and deleaded with dry $Na_2C_2O_4$. Equal volumes of the cleared and uncleared solutions were used in all comparisons. The sugars in a water solution were determined by Bertrand's modification of the Munson and Walker method. A period of a year elapsed between obtaining the results by the first and second workers.

The results, shown in Table I, obtained from cleared and uncleared solutions are within the usual error of duplicate sugar determinations. In the averages of the cleared extract as compared to the uncleared extracts, there are seven cases in which the uncleared average is less. Of course, it is possible for reducing substances other than sugar to be present which are not removed by the lead acetate. Results of a very similar nature with regard to acid hydrolyzable carbohydrates have been found by Morris and Welton (2).

Literature Cited

1. Kraus, E. J., and Kraybill, H. R. Vegetation and reproduction with special reference to the tomato. Ore. Agr. Exp. Sta. Bull. 149. 1918.
2. Morris, V. H., and Welton, F. A. The importance of clearing the hydrolyzed solution in the determination of acid-hydrolyzable carbohydrates in green plant tissue. Jour. Agr. Res. 33:195. 1926.

TABLE I—THE ACCURACY OF DETERMINING SUGARS OF TOMATO FRUITS IN UNCLEARED AS COMPARED TO CLEARED SOLUTIONS. SUGARS EXPRESSED AS MILLIGRAMS OF DEXTROSE (D—GLUCOSE).

	Sample	Cleared				Uncleared				Average Difference
Samples preserved in alcohol. Data obtained by Watson.	A	38.27	37.61	38.18	38.52	38.46	37.78	38.84	37.89	— .10*
	B	34.40				34.22				— .18
	C	24.03	23.90			23.91	24.12			+ .05
Juice of canned tomatoes. Data obtained by MacGillivray.	1	25.15	25.33	24.74		24.26	24.52	22.49		—1.32
	2	29.33	29.29	29.38		29.09	29.29	29.29		— .11
Samples preserved in alcohol. Data obtained by MacGillivray.	3	21.57	21.81	21.81		21.21	21.57	21.48		— .31
	4	25.51	25.29			25.24	25.15			— .20
	5	16.5	16.21			16.72	16.10			+ .06
	6	28.87	28.98			29.64	28.48			— .19

*Indicates that the average of the uncleared is less than the cleared.

Effect of Time of Planting Yellow Globe Danvers Onion Bulbs on Yield and Time of Maturity of Seed (Preliminary Report)

By S. L. Emsweller, *University of California, Davis, Calif.*

THE production of onion seed is an important part of the seed growing industry of California. Most of the acreage is found in the Santa Clara, San Joaquin, and Sacramento Valleys. The long dry season is particularly adapted to this crop, insuring excellent curing conditions and a minimum of diseases. The growers usually plant the mother bulbs of the regular storage types in late November and December. Poor keeping onions such as California Early Red and Italian Red are placed in cold storage until this time or are planted somewhat earlier. Occasionally mother bulbs are not planted until much later and there has been some question as to the best time to plant to secure the best quality and the heaviest yield of seed. Time-of-planting studies were therefore started in the fall of 1928 and it is planned to continue this work for a number of years.

Seed Yield

Bulbs from a selected strain of Yellow Globe Danvers were weighed separately and only those of uniform weight were used in the Experiment. In order to secure a sufficient number it was necessary to use bulbs that were a little more than one-half the size of those normally planted by growers. Each planting was replicated five times. The bulbs were set eight inches from center to center, and three inches deep in rows three feet apart. All plantings received uniform treatment with the exception of time of planting. The first lot was set on December 7th, 1928 and was followed by six other lots at approximately two week intervals until March 3rd.

As shown in Table I there is a somewhat consistent decrease in seed yield per plant from the earliest to the latest planting. The 2nd, 3rd, 4th, and 5th plantings all produced about the same yield of seed.

TABLE I—Influence of Planting Dates on Number of Seed Heads Per Plant and Seed Yield.

Date of Planting	Av. Wt. per Bulb Grams	No. Plants	Total No. Seed Heads	Av. No. Seed Heads per Plant	Av. Wt. Seed per Head Grams	Av. Seed Yield per Plant Grams	Seed Yield per Acre Pounds
12-7-28	40.3	201	541	2.69	5.40	14.55	694
12-27-28	40.4	198	480	2.42	5.43	13.16	611
1-2-29	40.4	199	453	2.28	5.66	12.88	609
1-22-29	40.3	200	510	2.55	5.07	12.93	611
1-30-29	40.5	203	489	2.41	5.35	12.88	620
2-15-29	40.5	194	478	2.46	4.76	11.73	540
3-2-29	40.5	198	497	2.51	4.20	10.55	496

Owing to weather conditions it was necessary to make these plantings within a period of five weeks. This was during a time of low temperatures which lasted until the first of February. It is very

likely that growth was delayed in these four plantings until the advent of warm weather. The average number of seed heads per plant did not decrease uniformly from the first to the last planting. The figures for yield per acre are based on the average yield per row. The general decrease in yield per acre fluctuates somewhat which can probably be explained as the result of the uneven stand. If each row is figured as having a perfect stand, the decrease in yield per acre drops rather uniformly with the exception of a slight fluctuation in the fourth planting.

Time of Maturity

The ripening period extended over several weeks and the heads were cut every few days. They were considered mature when approximately one-fourth of the capsules had opened disclosing the ripe seed within. The harvested heads of each row were placed in a sack which remained at one end of the row until all had been cut. At frequent intervals the sacks were shaken thoroughly and turned to facilitate drying and curing. When thoroughly dry the contents of each sack was threshed, cleaned, and weighed.

The first ripe heads were cut on July 7th and harvesting continued until August 9th. On July 7th there was a large number of ripe heads on the first few plantings as compared with the last ones. The percentage of heads harvested on each date is shown in Table II.

TABLE II—Rate of Ripening of Seed Heads, Expressed as Percentage of the Total Number of Heads Harvested.

Planting Dates	Per cent of Seed Harvested on							
	July 7	July 19	July 23	July 27	July 30	Aug. 2	Aug. 6	Aug. 9
12-7-28	15.5	37.5	60.1	69.5	81.3	93.3	99.4	100.
12-27-28	16.4	41.9	65.4	74.0	87.7	95.6	99.2	100.
1-2-29	13.5	52.3	65.3	77.3	88.7	94.7	99.3	100.
1-22-29	7.6	27.8	59.0	69.4	82.3	94.7	98.6	100.
1-30-29	7.4	26.0	55.0	67.5	77.7	92.2	97.5	100.
2-15-29	3.5	16.5	48.3	64.4	79.5	90.4	98.1	100.
3-2-29	.8	4.0	29.4	56.3	69.8	86.1	97.8	100.

By August 6th all plantings had ripened approximately the same percentage of their total yield. The earlier plantings showed a more uniform ripening throughout the harvesting period. Their peak of production was reached about the middle of July, while that of the late plantings was reached the last of July.

The earliness of ripening and the general increase in yield of seed of the early plantings over the late ones, is probably due to the growth of a more extensive root system which is established during the winter. The top growth was checked, but root development continued. Shortly after warm weather began, the tops all grew rapidly and it was impossible to distinguish the early from late plantings.

Effect of Ethylene on the Growth of Celery

By R. B. Harvey, *University of Minnesota, St. Paul, Minn.*

THE work of Neljubow (1, 2) shows that ethylene and related hydrocarbons remarkably affect the growth of plants and their responses to stimuli. The effects of these hydrocarbons on the sensitive reactions of seedlings was further investigated by E.M. Harvey (3).

Some objection has been found in the application of ethylene for the blanching of celery because of lack of growth of the inner stalks of the bunches. If celery is blanched by hilling or by other coverings, such as paper or boards, considerable time is required for blanching. Cutting off the sunlight during this period allows the stalks to stretch up and causes an increased rate of growth in the heart stalks. The shorter time required by the ethylene process, namely, 3 to 4 days, does not allow any considerable growth of the hearts.

This was attributed to the effect of ethylene, but, as a matter of observation, the hearts of cut celery, whether exposed to ethylene or not, grow very little unless stored in trenches where there is high humidity.

Ethylene does check the growth of celery. Plants grown in pots were transferred from the greenhouse to two chambers in darkness at 65 degrees F. One set received 1–1000 ethylene for five days, the concentration being renewed each day. The other chamber was used for checks and kept at the same temperature for the same time. At the end of five days all of the stalks in the checks had stretched up several inches in the dark, while the plants exposed to ethylene had not increased appreciably in length. The Neljubow reaction was clearly shown by the celery treated with ethylene; the stalks were curved sharply downward, owing to growth on their upper sides. The leaves were blanched much more than those of the check plants (Fig. 1).

In tests on young plants of different varieties the seedling stages showed great differences in the blanching reaction with ethylene (Fig. 2). The self-blanching sorts, even in the seedling stages, are chlorotic, and when exposed to ethylene they blanch more readily than the greener varieties. It should be possible by this blanching test to determine before the crop of a variety is grown, what its blanching characteristics will be. Such a method may be used to separate in the seedling stage those plants which are likely to give strongly self-blanching strains, which usually also grow poorly.

This blanching reaction has been used also on leaves of other plants which were infected with recognized mosaic disease. Young plants of potato, sweet clover, and tobacco with known mosaic and with healthy check plants were exposed to the same concentration of ethylene with all other conditions the same. Those with known mosaic infection blanched more quickly than healthy leaves. This similarity of the conditions in celery and in known mosaic diseased plants in blanching is taken as further evidence of the statement in a former publication (4) that "the self-blanching condition in celery is aided by mosaic infection." It seems that this chlorotic tendency is seed borne.

LITERATURE CITED

1. NELJUBOW, D. Ueber die horizontale nutation der Stengel von Pisum sativum und einiger anderin Pflanzen. Beih. Bot. Centralbl. 10: 128. 1901.
2. ————. Geotropismus in der Laboratoriumsluft. Ber. Deutsch. Bot. Ges. *29:* 97. 1911.
3. HARVEY, E. M. Some effects of ethylene on the metabolism of plants. Bot. Gaz. 60: 193. 1915.
4. HARVEY, R. B. Blanching celery. Minn. Agr. Exp. Sta. Bul. 222. 1925

Catalase Activity and the Rate of Growth of Tomato Fruits

By F. D. GUSTAFSON, INEZ CLARK, and D. A. SHAW,
Ann Arbor, Mich.

The material contained in this paper will probably be published in the Journal of Plant Physiology.

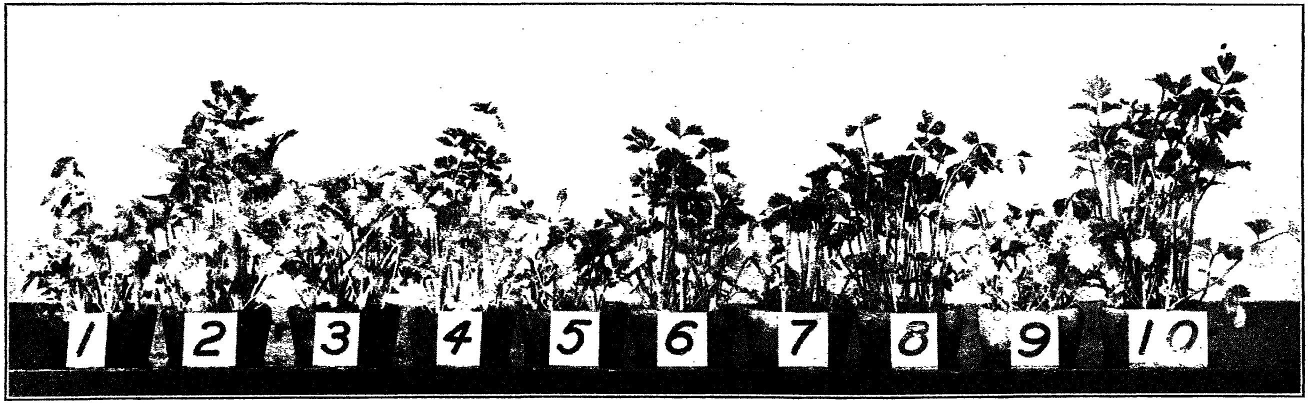


FIG. 1.

Odd numbers treated with ethylene, 1–1000, at 65°F. for five days.

Even numbers, checks from the same lot and the same size at start, kept at 65°F. in the dark for five days.

1 and 2. Golden Plume (Stokes).
3 and 4. Michigan Golden Self Blanching.
5 and 6. Golden Crisp.
7 and 8. Leicester Red.
9 and 10. Clayworth's Prize Pink.

Note the dwarfing in the odd numbered pots and also the curving of the petioles.

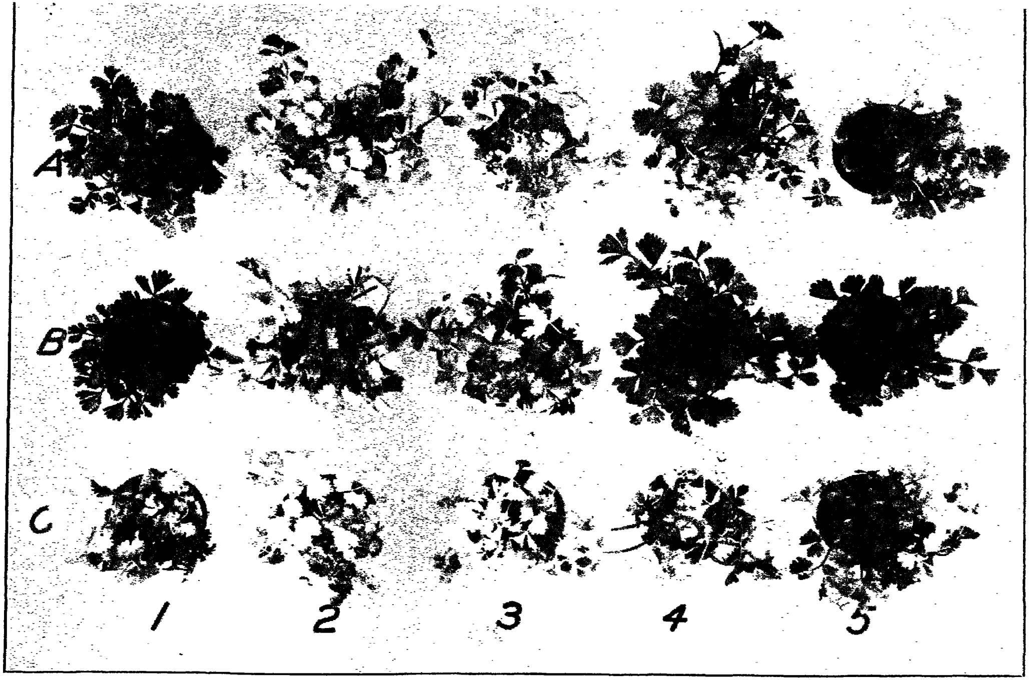


FIG. 2.

No. 1. Golden Flume (Stokes).
" 2. Michigan Golden Self Branching.
" 3. Golden Crisp.
No. 4. Leicester Red.
" 5. Clayworth's Prize Pink.

Row A. Kept in darkness at 65 degrees F. for five days.
Row B. From greenhouse, to show naturally chlorotic seedlings.
Row C. Kept in darkness at 65 degrees F. for five days with ethylene, 1–1000, renewed each day.

The Use of Dyes in Coloring Flowers and Ornamentals

By R. B. Harvey, *University of Minnesota, St. Paul, Minn.*

THE number of dyes which can be used to color cut flowers is relatively limited and their production has been mostly a trade secret. St. Patrick's Green has been the most successful color in use. Without going into the merits of various dye preparations, the author presents data on the absorption, toxicity, and range of color which can be obtained by certain new non-toxic dyes.

For five years Light Green S. F. has been used in Elementary Physiology classes at the University of Minnesota to demonstrate the conduction path in stems, fruits, etc. This dye penetrates more rapidly than other dyes, such as eosin, which have been used for such purpose. Furthermore, it is not poisonous. A jar of water solution of this dye, .2 gm. to 200 cc. of water, was sunk into the ground and a small root of a plum tree cut and immersed in it. Within 48 hours the dye had passed up thru the trunk and limbs about 9 feet. The dye was localized in the trunk to the section which corresponded to the attachment of the root. One branch of the tree was more deeply colored than others; in some no dye could be detected by color in the wood. The buds on this plum tree had not opened, but did so within five days after the dye was applied. When the flower buds opened they were colored bluish green by the dye. Fruits set on these flowers and grew to normal size. The leaf buds, when they opened, also showed a bluer green color than normal, owing to the presence of the dye. The leaves persisted thruout the summer and fell only at the usual period in autumn. Hence, it seems that Light Green S. F. is not particularly poisonous and allows normal development.

Light Green S. F. penetrates about one foot in five minutes in freshly cut stems of sweet peas. An hour is a sufficient time to give a deep coloration of the flowers of most plants. The rate of penetration is determined by the rate of water loss from the flowers and the degree of opening of the tracheal tubes.

The dye accumulates in places where breaking of the cuticle or injury has occurred. Insect punctures and fungus spots may be marked by accumulation of Light Green S. F. and by other dyes, such as Brilliant Blue, Ponceau 3 R, and Acid Fuchsin. These dyes accumulate in places where the transpiration rate is high, such as at the tips of wheat leaves, at the hydathodes, and in leaf and flower surfaces which have a thin cuticle.

The dye accumulation in leaves is a function of the intensity of the light exposure. The portion of a leaf exposed to the direct sunlight becomes more deeply stained than a part turned at an angle to the sun. By focusing the image of an incandescent light upon the leaf through a lens, a picture of the filament is produced on the leaf by the accumulation of dye. A current of air blown onto the evaporating surface causes an accumulation of dye at the spot where the air current impinges. A photograph varying in intensity of its shadows can similarly be produced on a leaf by projecting through a stereopticon.

It seems, then, that dye accumulation can be used to demonstrate differences in the rate of transpiration at different spots on flowers and leaves. The function of floral parts, glumes, etc. as structures for securing transpiration can be nicely demonstrated by the dye accumulation method.

Of several hundred dyes tested, those which give most rapid penetration and least toxicity are as follows:

Light Green S. F., bluish green; Brilliant Blue, deep clear blue; Ponceau 3 R, deep purplish red; Tartrazine, brilliant lemon yellow; Amaranth, purplish red; Acid Fuchsin, purplish red; Orange G, light yellow.

This list covers a range of spectral colors so that almost any color can be obtained by mixing two dyes in different proportions. Thus, Tartrazine and Light Green S. F. in equal concentrations gives a very attractive green for St. Patrick's Day decorations.

Effects of Nitrogen, Phosphoric Acid, and Potash Applications on Yields and Circumference Growth in Ensembled Data from Cultivated Apple Orchards

By FRED W. HOFMANN, *Virginia Agricultural Experiment Station, Blacksburg, Va.*

INSOFAR as safety increases with numbers, more reliable conclusions may be ventured with a larger number of compared cases. For the purpose of ascertaining on a larger scale, the effects of certain treatments in cultivated apple orchards involving nitrogen alone; nitrogen and phosphoric acid; nitrogen and potash; and nitrogen, phosphoric acid, and potash, various ensembles of Virginia data along with those of West Virginia, Pennsylvania, and New York were made.

Four experimental orchards of Virginia as well as several (1, 2, 3, 4) West Virginia, Pennsylvania, and New York experimental orchards show some odds in favor of a nitrogen, phosphoric acid, and potash combination, though not convincingly. The data of similar treatments brought together in ensembles with increased number of cases for comparison should be helpful for more convincing conclusions. With the exception of the New York orchards all of the orchards used in these ensembles are in a great limestone section which, according to the Bureau of Soils (5), has its beginning in New York and running in a southwest direction ends in Alabama. In this regard, the Virginia, West Virginia, and Pennsylvania orchards are in very much the same general soil type. Ensembled data including some of the experimental orchards from these states and even New York should be helpful in providing a larger number of cases for comparison and thereby revealing some particulars of a more or less special and general nature insofar as certain fertilizer needs in apple orchards of this section may be concerned.

The separate fertilizer experiments in these states show that application of nitrogen alone, and in combination with either or both phosphoric acid and potash, produce rather consistent responses with apple trees under cultivation insofar as gains in yield and circumference increases are concerned. Although the odds in the separate cases may be too low and consequently regarded as insignificant, it is very likely that the separate tendencies to favor a certain treatment when collected in an ensemble may be accepted as showing significant gains.

Records from the following orchards were used to collect the ensembles of Tables I and II. From Virginia: Blacksburg, Crozet, Melvin Green and Round Hill Experimental Orchards. From West Virginia: Sleepy Creek Experiment with Grimes, Ben Davis, and York; and St. Mary's Rome Orchard. From Pennsylvania: Projects 215, 216, and 461. From New York: Densmore-Chapman, Vick-Auchter, and Rome Beauty Experiment Orchards.

TABLE I—ENSEMBLE YIELDS OF APPLE TREES IN CULTIVATION, TREATED PLOTS COMPARED WITH UNTREATED PLOTS

Fertilizer* Combination Compared	Average Yield Pounds for Treatment	Average Yield Pounds for Check	Gain Pounds for Treatment	Number of Years Compared	Students Odds to 1
York—From Blacksburg, Crozet and Green Orchards, Virginia; Sleepy Creek Experiment, West Virginia; and Projects 215 and 216, Penna.					
N with C	222	238	—16	20	3.56
NP with C	218	214	4	20	4.4
NK with C	259	223	36	21	102.3
NPK with C	267	173	94	21	9999.0
Grimes—From Blacksburg, Virginia; and Sleepy Creek Experiment, West Va.					
N with C	124	102	22	12	93.44
NP with C	108	101	7	12	2.06
NK with C	117	101	16	12	3.48
NPK with C	115	101	14	12	2.84
Stayman—From Blacksburg and Crozet, Va.; and Projects 215 and 216, Penna.					
N with C	192	137	55	20	54.58
NP with C	181	183	—2	19	0.0
NK with C	246	152	94	18	195.0
NPK with C	240	167	73	19	28.0
Winesap—From Blacksburg and Crozet, Virginia					
N with C	111	45	66	10	13.06
NP with C	137	49	88	10	29.8
NK with C	162	49	113	9	31.58
NPK with C	160	49	111	10	81.0
Ben Davis—From Sleepy Creek Experiment, W. Va.; and Round Hill Orchard, Va.					
N with C	201	134	67	15	21.78
NP with C	109	59	50	11	44.22
NK with C	124	50	74	11	138.0
NPK with C	147	50	97	11	527.2
Rome Beauty—From N. Y. Experiment Station, N. Y., and St. Mary's Experiment, W. Va.					
NPK with C	413	343	70	24	Infinity
Baldwin—From New York and Pennsylvania					
NPK with C	552	573	—21	10	1.7
York, Grimes, Stayman, Winesap and Ben Davis—From Blacksburg, Crozet and Round Hill, Virginia; and Pennsylvania					
N with C	170	141	29	21	39.66
NP with C	157	143	14	20	4.08
NK with C	195	135	60	20	752.4
NPK with C	184	124	60	21	311.6
York, Grimes, Stayman, Winesap, Ben Davis, Rome Beauty, Baldwin and Jonathan—From Virginia, West Virginia, Pennsylvania, and New York					
N with C	261	214	47	21	1356.4
NP with C	236	197	39	21	67.4
NK with C	232	168	64	21	1356.4
NPK with C	275	215	60	25	Infinity

*N = Nitrogen; P = Phosphoric Acid; K = Potash; C = Check or Untreated.

TABLE II—ENSEMBLE CIRCUMFERENCE INCREASES OF APPLE TREES IN CULTIVATION, TREATED PLOTS COMPARED WITH UNTREATED PLOTS

Fertilizer* Combination Compared	Average Increase in Inches for Treatment	Average Increase in Inches for Check	Gain in Inches for Treatment	Number of Years Compared	Students Odds to 1 in Favor of Treatment
York—From Blacksburg and Crozet, Virginia; Sleepy Creek Experiment, West Virginia; and Projects 215 and 216, Pennsylvania					
N with C	1.70	1.5	.20	14	77.7
NP with C	1.75	1.5	.25	12	Infinity
NK with C	1.65	1.5	.15	11	16.2
NPK with C	1.69	1.5	.19	12	72.94
Grimes—From Blacksburg, Virginia and Sleepy Creek Experiment, West Va.					
N with C	1.69	1.41	.28	13	32.4
NP with C	1.64	1.41	.23	11	114.0
NK with C	1.50	1.41	.09	12	12.5
NPK with C	1.49	1.41	.08	11	6.41
Stayman—From Blacksburg and Crozet, Virginia; and from Sleepy Creek Experiment, West Virginia					
N with C	1.93	1.57	.36	13	Infinity
NP with C	2.05	1.57	.48	15	Infinity
NK with C	1.78	1.57	.21	14	31.74
NPK with C	1.95	1.57	.38	14	Infinity
York, Grimes and Stayman—From Virginia, West Virginia and Pennsylvania					
N with C	1.76	1.46	.30	15	1044.4
NP with C	1.69	1.46	.23	15	1180.8
NK with C	1.61	1.52	.09	13	40.48
NPK with C	1.65	1.52	.13	14	4999.0
York, Grimes, Stayman and Winesap—From Virginia, West Virginia and Penna.					
NK with C	1.39	1.19	.20	14	790.4 ¶$
York, Grimes, Stayman, Winesap and Rome Beauty (3 New York Orchards—From Virginia, West Virginia, Pennsylvania and New York					
N with C	1.53	1.21	.32	15	Infinity
NP with C	1.38	1.13	.25	15	1699.0
York, Grimes, Stayman, Winesap and Rome Beauty (3 New York Orchards)—From Virginia, West Virginia, Pennsylvania and New York					
NPK with C	1.33	1.20	.13	16	8999.0

*N = Nitrogen; P = Phosphoric Acid; K = Potash; C = Check or Untreated.

Ensemble yield averages were calculated for the respective treatments and compared with corresponding check averages. York yields show significant gains for a nitrogen and potash, and a nitrogen, phosphoric acid, and potash treatment. Grimes show significant gains for nitrogen alone and some odds in favor of nitrogen, phosphoric acid, and potash. Staymans show significant gains for nitrogen alone, nitrogen, and potash and some odds in favor of nitrogen, phosphoric acid, and potash. Winesaps show significant odds for nitrogen and potash, and for a nitrogen, phosphoric acid, and potash treatment, and noticeable odds in favor of nitrogen and phosphoric acid. Ben Davis shows significant gains for a nitrogen and phosphoric acid, nitrogen and potash, and nitrogen, phosphoric acid, and potash treatment. Rome Beauty shows significant gains for nitrogen, phosphoric acid, and potash. Baldwin shows very slight odds for a nitrogen, phosphoric acid and potash treatment. York,

Grimes, Stayman, Winesap, Ben Davis, Rome Beauty, and Baldwin taken as a whole show significant gains for nitrogen alone but higher odds and higher gains for a nitrogen and potash, and a nitrogen, phosphoric acid, and potash treatment. As a general proposition a nitrogen, phosphoric acid, and potash treatment show higher gains in yield and higher odds.

York shows significant gains in circumference increase for nitrogen alone, nitrogen and phosphoric acid, and nitrogen, phosphoric acid, and potash. Grimes shows significant gains for nitrogen alone and a nitrogen and phosphoric acid combination. Stayman shows significant gains for nitrogen alone, and a nitrogen, phosphoric acid, and potash treatment. York, Grimes, and Stayman taken together show odds in favor of nitrogen alone, and a nitrogen, phosphoric acid, and potash treatment. The highest responses for the variety ensemble show up with nitrogen alone, a nitrogen and phosphoric acid, and a nitrogen, phosphoric acid, and potash treatment. A significant gain in trunk circumference, however, also shows up for nitrogen with potash. The odds are highest in favor of nitrogen, phosphoric acid, and potash.

On the whole over the entire limestone apple sections studied, there are significant gains in yield and trunk increase when some combination of nitrogen with either phosphoric acid or potash or both is applied in cultivated apple orchards. The odds are generally more in favor of a complete combination.

Literature Cited

1. Dorsey, M. J., and Knowlton, H. E. Fertilization of apple orchards, II. W. Va. Agr. Exp. Sta. Bul. 203. 1926.
2. Anthony, R. D., and Waring. Methods of interpreting yield records in apple fertilization experiments. Pa. Agr. Exp. Sta. Bul. 173. 1922.
3. Collison, R. C. A progress report of fertilizer experiments with fruits. N. Y. Agr. Exp. Sta. Bul. 477. 1920.
4. Hedrick, U. P., and Tukey, H. B. Twenty-five years of fertilizers in a New York apple orchard. N. Y. Agr. Exp. Sta. Bul. 516. 1924.
5. Winston, R. A., and Lee, Ora, Jr. Soil survey of Montgomery County, Virginia. Bureau of Soils. 1908.

The Relation of Cultural Practices to a Marked Outbreak of Cork in McIntosh Apples in Northern New England

By L. P. LATIMER, *University of New Hampshire, Durham, N. H.*

IN the season just past (1929) one of the leading New Hampshire apple growers lost 300 bushels of McIntosh apples from the disease known as Cork. Several other growers in the state and in nearby sections of Maine also reported the occurrence of the disease.

Certain phenomena noted in relation to this occurrence tend to support some of the conclusions made by Mix (2) concerning the possible cause of Cork and related diseases. He states, "...it is suggested that the exact manner of occurrence of the injury may be by the leaves robbing the fruit of water during a critical period of root supply and high transpiration." It seems to the writer that just such conditions occurred in the summer of 1929, in the regions of New Hampshire where Cork in apples was prevalent.

The varieties reported as being affected were McIntosh, Cortland, Gravenstein, Wealthy, and Delicious. It is possible that the trouble was not restricted to these varieties but was noted in them because of the numbers in which they are planted and their commercial importance. Cortland apples were much more severely injured than any other variety. McIntosh was second, and Wealthy, Delicious, and Gravenstein were affected the least in this group.

In the most severe cases (Cortland) the tissues of the fruit were badly affected, and spots of cork were scattered throughout the fruit. Externally the fruit showed a very rough surface with a large number of deep depressions. In the worst cases the fruit was misshapen, showing a decidedly ribbed appearance. The Cortland apples were affected apparently in the same way as, but more severely than, the Fameuse apple fruits described by Mix (2). In the McIntosh apples external appearances were those of a normal, sound fruit. Only by cutting them open could evidences of Cork be detected. In most cases the fruit from an affected tree was badly spotted internally, appearing more like that illustrated by Brooks and Fisher (1). The other varieties affected in Northern New England appeared more like the McIntosh, showing no external evidence of injury and somewhat less intense internal spotting.

This disease, where noted, occurred in orchards on rather shallow soils on hillsides or in hilltop orchards where conditions were not favorable for storing much water in the soil. In every case the trees had made vigorous shoot growth during a period of abundant rainfall early in the season. About the last part of July an extended period of drouth set in. Clear skies and high temperature marked the period. When this period of drought began, apples (McIntosh and Cortland) had attained an average diameter of 1 to 1½ inches. Cultivated soil or soils that were heavily fertilized, (when fairly shallow, on a good slope overlying granite ledge) seemed to favor the development of the most severe cases. Trees in such locations lost their

leaves (except near the tips of new shoots) earlier in the season than unaffected trees. In most cases the trees with fruit suffering from Cork were 10 to 20 years of age, and the grower had no record of any previous occurrence of the disease where these trees were planted.

Literature Cited

1. Brooks, Charles and Fisher, D. F. Irrigation experiments on apple spot disease. Jour. Agr. Res. 12: 109–137. 1918.
2. Mix, A. J. Cork, drouth spot and related diseases of the apple. N. Y. Agr. Exp. Sta. Bul. 426. 1916.

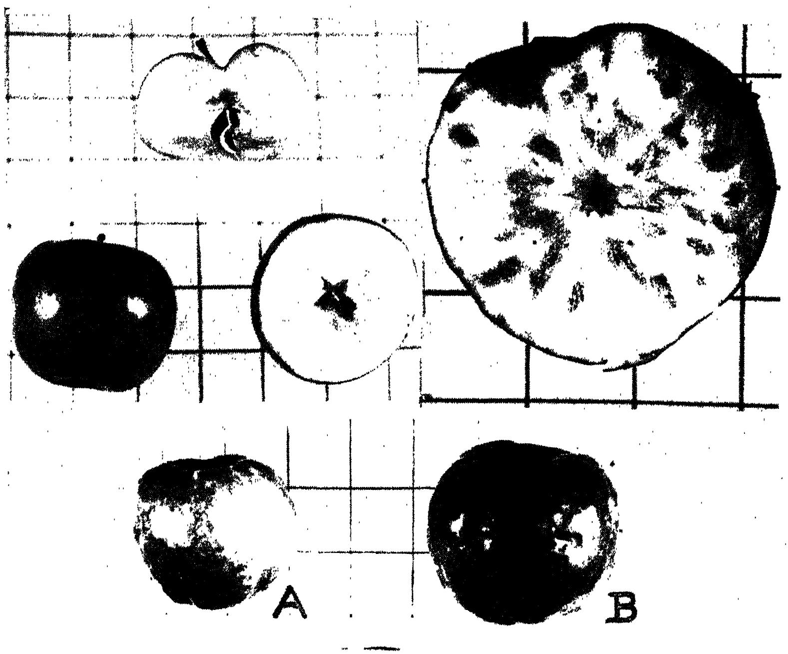


FIG. 1.

Upper lelt: McIntosh apples. Fruits mature, 2½ inches in diameter, external surface smooth, flesh cork spotted especially towards the core.

Upper right: Cross section of Cortland apple affected severely with Cork. Dried out spots and lesions throughout the tissue, perpendicular to central axis.

Lower left: A. Cortland apple, depressions in surface. Apple deformed and ribbed, severe cork spots throughout flesh.

Lower right: B. Apple, Cortland, affected with Cork internally. Surface rough and covered with large medium deep depressions.

Some Orchard Soil Nitrate Relations[1]

By R. J. Barnett, *Kansas Agricultural Experiment Station, Manhattan, Kans.*

EXPERIMENTAL work on orchard soil management has been carried on for the past ten years by the department of horticulture of the Kansas Agricultural Experiment Station. The principal systems studied have been commercial fertilizers plus barn-yard manure or a rye cover crop, clean cultivation plus various legume and non-legume cover crops, and straw mulch. Records taken have included nitrate and moisture contents and temperature of the soil as well as twig growth, trunk growth, and fruit yield of the trees.

It is not the writer's intention to make any general review of these data in this paper but merely to call attention to a brief side-line study which was made during 1928 and 1929. A common criticism of orchard soil work with nitrates has been that the experimenter was dealing with residues only; that his analyses did not show the nitrates formed or those normally present in the soil but merely those left over after the capacity of the tree's roots to appropriate them had been satisfied. These critics also expressed the opinion that the differences in nitrate content would be less between soils given varying treatments and occupied by tree roots than between soils given parallel treatments with the first set but free from tree roots.

TABLE I—Average Nitrates in Parts Per Million in 1928.
(Surface Three Feet)

		Plot Number			
		I	II	III	IV
March	11	14	28	23	27
	24	71	60	41	23
April	4	40	56	30	29
	18	28	39	27	25
May	2	32	33	31	37
	10	30	36	35	27
	23	42	30	42	52
June	7	53	32	64	49
	15	27	54	41	45
	21	29	29	55	44
	27	44	57	52	39
July	5	28	42	42	41
	25	16	36	54	33
August	2	33	45	44	30
	21	19	39	51	38
Sept.	15	27	89	78	62
October	1	31	36	48	40
	19	21	78	46	26
November	4	17	41	38	33
	23	11	32	46	37

To test out this relation, four plots were laid out close together, two of them under straw mulch and two clean cultivated. They were all in the same position relative to 15-year-old Delicious apple

[1]Contribution No. 88. Department of Horticulture.

trees. One plot in each pair was trenched entirely around early in the spring to a depth of 4 feet and this trench was opened up sufficiently frequently each summer to prevent tree roots from growing into it. All weed growth was eradicated on the cultivated plots and the straw kept down such growth on the other pair.

Plot I was under old straw mulch and had tree roots excluded. Plot II was like I except that there was a natural distribution of tree roots in it. Plot III was under clean cultivation treatment, tree roots excluded; and plot IV was clean cultivated with a natural distribution of tree roots.

In 1928 duplicate samples were taken from each plot to a depth of three feet and the nitrate content determined[2] on 20 dates. The first of these was March 11, before tree growth had started, and the last was November 23. These data are shown in Table I and indicate no clear relation between the nitrate content of an orchard soil and the presence or absence of tree roots in that soil. Until in June, when the principal twig growth of the trees was completed, the lead in nitrates fluctuated between the two treatments in both pairs of plots. Subsequent to that date, plot I, straw without roots, showed a lower nitrate content than plot II, straw with tree roots. In contrast plot III, clean cultivation without roots, was consistently higher in nitrates than plot IV, clean cultivation with tree roots.

The data from eight nitrate determinations in 1929, the same plots being used, are shown in Table II.

TABLE II—NITRATES, PARTS PER MILLION IN 1929.
(Surface Three Feet)

Plot No.	March 21	April 13	May 2	May 16	June 14	July 5	July 19	August 13
I	36	48	29	47	32	29	23	35
II	80	65	34	38	42	52	38	51
III	75	85	29	42	32	36	20	40
IV	77	29	36	51	40	40	33	35

These, in a general way, correspond with the results obtained in 1928 except that plot IV, clean cultivation with roots, tends to excel plot III in nitrate content during midsummer whereas it was lower than plot III in 1928.

Although these experiments are not extensive or long continued enough to settle the question whether the experimenter with orchard soil nitrates is merely dealing with nitrate residues, they do indicate that other factors than the absorption of nitrates by the tree roots are potent in the soil nitrate relation. It is even possible that under conditions favorable for nitrification the absorption of nitrates by tree roots acts as a stimulus to the nitrifying soil organisms and so tends to maintain the supply as occurred in three of the four tests here recorded. Plots I and III, roots excluded but under different methods of soil management, are but little more consistent in nitrate content than are plots II and IV, in fact, no strong justification for the criticism mentioned early in this paper can be based on these data.

[2]These determinations were made by assistants G. W. Amstein and L. W. Koehler.

Profitable Application of Certain Fertilizers to Apple Orchards in the Hagerstown Soil Series

By Fred W. Hofmann, *Virginia Agricultural Experiment Station, Blacksburg, Va.*

BROWN'S (1) citations along with his own independent work indicate that a hundred pounds of apples remove .059 pounds nitrogen, .027 pounds phosphoric acid, and .16 pounds potash from the orchard soil. Thompson (2) shows that the foliage and wood of 40 apple trees take up .08 pounds nitrogen, .02 pounds phosphoric acid, and .06 pounds potash the first years after setting out in the orchard; 11.85 pounds nitrogen, 5.74 pounds phosphoric acid and 14.22 pounds potash the ninth year after setting; and 28.10 pounds nitrogen, 9.26 pounds phosphoric acid, and 27.22 pounds potash for the entire nine years. Thompson also states that in these nine years 12.84 pounds nitrogen, 2.53 pounds phosphoric acid and 12.97 pounds potash are returned to the soil by the foliage, leaving a net removal of 15.26 pounds nitrogen, 6.73 pounds phosphoric acid and 14.25 pounds potash.

TABLE I—Approximate Amount of Nitrogen, Phosphoric Acid, and Potash in Wood of Apple Trees of a Given Circumference, Blacksburg, Va.

Circumference Inches	Nitrogen Pounds	Phosphoric Acid Pounds	Potash Pounds
1	.01	.004	.009
2	.02	.005	.01
3	.03	.008	.02
4	.05	.015	.04
5	.09	.025	.06
6	.1	.03	.08
7	.2	.045	.1
8	.3	.05	.2
9	.4	.08	.3
10	.5	.12	.4
11	.6	.15	.5
12	.7	.18	.6
13	.9	.25	.7
14	1.0	.35	.9
15	2.0	.45	1.0
20	5.0	1.0	4.0
25	11.0	3.0	9.0
30	20.0	6.0	16.0
35	31.0	9.0	23.0
40	44.0	13.0	34.0
45	54.0	15.0	42.0
50	68.0	20.0	52.0
55	85.0	25.0	65.0
60	102.0	30.0	78.0
65	122.0	36.0	94.0
70	143.0	42.0	109.0
75	170.0	50.0	130.0
80	201.0	59.0	154.0
85	238.0	70.0	182.0
90	291.0	85.0	221.0
95	340.0	100.0	260.0
100	364.0	110.0	286.0

Approximations have been made by the writer for the amounts of the three elements taken up in wood by the time apple trees reach a given circumference. These are brought out in Table I. Average crop yields for trees of different circumference were estimated, and on the basis that 100 pounds of fruit use up .059 pounds nitrogen, .027 pounds phosphoric acid, and .16 pounds potash, the total amounts of these three elements taken up over certain periods are indicated in Table II. According to the approximations in Table II, by the time a tree has grown to 40 inches in circumference its wood will have taken up 44 pounds nitrogen, 13 pounds phosphoric acid, and 34 pounds potash. With a total yield of 6,000 pounds of apples, an additional 3.5 pounds nitrogen, 1.6 pounds phosphoric acid, and 9.6 pounds potash will be withdrawn making a total removal of 47.6 pounds nitrogen, 14.5 pounds phosphoric acid, and 43.6 pounds potash in a period of some 25 years.

TABLE II—APPROXIMATE AMOUNTS OF NITROGEN (N), PHOSPHORIC ACID (P_2O_5), and POTASH (K_2O) TAKEN UP BY TREES OF A GIVEN CIRCUMFERENCE WITH A GIVEN TOTAL YIELD.

Age Years	Size of Circumference Inches	Total Average Yield of Crop Pounds	Amount of Elements in Pounds Taken Up			
				N	P_2O_5	K_2O
1–6	1–11		In wood	.5	.12	.4
			In fruit	0	0	0
			Total	.5	.12	.4
6–11	11–21	500	In wood	5.0	1.0	4.0
			In fruit	.3	.14	.8
			Total	5.3	1.14	4.8
11–16	21–31	2,000	In wood	20.0	6.0	16.0
			In fruit	1.2	.5	3.2
			Total	21.2	6.5	19.2
16–21	31–36	3,500	In wood	31.0	9.0	23.0
			In fruit	2.0	1.0	5.6
			Total	33.0	10.0	28.6
21–26	36–41	6,000	In wood	44.0	13.0	34.0
			In fruit	3.5	1.6	9.6
			Total	47.5	14.6	43.6
26–31	41–46	10,000	In wood	54.0	16.0	42.0
			In fruit	5.9	2.7	16.0
			Total	59.9	18.7	58.0
31–36	46–51	15,000	In wood	68.0	20.0	52.0
			In fruit	8.9	4.0	24.0
			Total	76.9	24.0	76.0

From what has been brought out in these studies, certain practical applications in regard to the use of fertilizers for apple orchards in soils like those of the Hagerstown series at Blacksburg may be considered. According to the analysis made by the Chemistry Department of the Virginia Agricultural Experiment Station, there is shown to be available as plant food 900 pounds nitrogen, 61 pounds

phosphoric acid, and 450 pounds potash to an acre of soil of the Hagerstown series, when the fifth normal nitric acid method to determine availability for plant food was used. This soil should provide to apple trees planted 40 feet apart approximately 41.6 pounds nitrogen, 2.24 pounds phosphoric acid, and 16.8 pounds potash. The fusion method of analysis shows an abundance of phosphoric acid and potash but according to the fifth normal nitric acid solubility method, the amounts present in available form as plant food are inadequate to maintain capacity growths and crops for apple trees planted 40 feet apart after they have reached a 40-inch trunk circumference or approximately after some 25 years as shown in Table II. Unless the elements that are present can be made available by the growth of certain cover crops or other cultural practices, by the time apple trees planted at such distances extend their root systems so that they meet each other, all of the available nitrogen, phosphoric acid, and potash in this occupied area will have been exploited. Furthermore, the roots will occupy this area to such an extent that the trees will be somewhat like root-bound potted plants. All of these conditions cause the supply of nitrogen, phosphoric acid, and potash to become limited ultimately in such soils to the extent that the apple trees are slowly pushed to a physiological limit. From then on they most likely will go on a down grade into old age or senescence unless the soils are more fertile in available plant food than shown in the aforementioned analysis or certain cover crops are grown and certain cultural methods employed which may release the locked up elements or provision made for the gradual and ultimate depletion of these essential elements by adequate soil fertilization.

Apple trees may be planted at greater distances than 40 feet to exploit larger areas. However, planting distances exceeding 40 feet are not practical when orcharding is more profitable on an acreage basis rather than on the basis of the tree as a unit. Since the extent to which soils will be depleted may be ascertained insofar as crop removal alone is concerned, it should be profitable for capacity growths and yields to anticipate the later needs of apple trees by gradually applying fertilizers that contain the essential elements in amounts that at least correspond to their removal in fruit. In addition to the removal of the essential elements in fruit, the removal in pruning and trimming should also be considered. Other cultural practices such as the growing of certain cover crops may also be profitable.

This leads to the question: To what extent will the application of fertilizers containing the essential elements, namely, nitrogen, phosphoric acid and potash be profitable to soils of the Hagerstown series such as those at Blacksburg? In attempting an answer to this question, reference may be made to the analysis heretofore mentioned which shows the amount of nitrogen, phosphoric acid, and potash in the fruit of apples. With the analysis of fruit available, profit may be determined on the basis of the amount of these essential elements found in a given amount of fruit and figuring the

cost of fertilizers necessary to provide these elements as against the price that can be received for this given amount of fruit. If, for example, as is shown by the analysis mentioned, there are present in 100 pounds of apples .059 pounds nitrogen, .027 pounds phosphoric acid, and .16 pounds potash, the cost of .395 pounds sodium nitrate, .168 pounds 16 per cent acid phosphate, and .33⅓ pounds 48 per cent potassium sulphate or other fertilizers containing these three essential elements in equivalent amounts, as against what 100 pounds of fruit can be sold for, should determine the profit that may be realized as far as the application of fertilizers alone are concerned. Upon the basis of the elements removed by harvested crops, applications can be made in conservative amounts and the normal or original fertility of the soil reserved for other growth needs. Of course, if the purpose is to get all possible profits at the expense of the gradual removal of these elements without regard for the ultimate fertility of the soil, it may not be profitable to restore the fertility removed, particularly in the richer soils or when costs of fertilizers are relatively high. As long as the fertilizers necessary to provide the essential elements removed in crops are cheap as compared to the prices that can be received for crops, it should be profitable and advisable for continued needs to return the elements removed. It should also be good business to have available in the soil a sufficient reserve of these elements in the form of cheaper raw products which are to be converted into a finished product, namely, the apple and in this form to be sold at a higher price.

As a general proposition, complete fertilizer combination applications containing nitrogen, phosphoric acid, and potash show higher crop gains for apples throughout this limestone belt. Applications of nitrogen alone, however, give more pronounced rates of gains. Inasmuch as apples from nitrated plots are generally delayed in maturity and very likely as a consequence lack finish and the ability to hold up as well as apples grown in plots where nitrogen is lower in proportion, phosphoric acid and potash should not be entirely overlooked in spite of lower rates of gain as shown when nitrogen alone is used. On the other hand, nitrogen is generally a limiting factor, particularly in soils like those studied herein. Thus, in considering the application of fertilizers to soils like those of the Hagerstown series upon the basis of the removal of nitrogen, phosphoric acid, and potash in harvested crops, insofar as these applications will be profitable from the standpoint of maintaining a ready reserve of available plant food in the form of a cheaper raw product to be sold at a relatively higher rate as a finished product, and in considering the greater ease with which nitrogen is generally lost, there should be added to such soils as a minimum for every thousand pounds of fruit removed, .6 pounds nitrogen or 4 pounds sodium nitrate, .16 pounds phosphoric acid or 1 pound of 16 per cent acid phosphate, and .48 pounds potash or 1 pound of 48 per cent potassium sulphate per tree. Other fertilizers containing these essential elements in equivalent amounts in the ratio of approximately 7 to 2 to 5 of nitrogen, phosphoric acid, and potash respectively, may, of course,

be used instead. This affords a conservation rate of application, allows for a more definite comparison of the cost of the amount of these fertilizers as against the price of the 1,000-pound fruit crop that will be provided for, and shows what profits may be realized insofar as the cost of these fertilizers alone is concerned. In addition to needs based on fruit alone as a minimum and to take care of, removal from pruning and cover crop needs, a 7–6–5 formula for poorer soils not planted to legumes and a 4–8–7 formula for richer and legume planted soils, may be suggested when ammonia is figured in these formulae.

LITERATURE CITED

1. BROWN, C. A., JR., Pa. Dept. Agr. Rpt. Pt. 1, 547. 1899.
2. THOMPSON, R. C. Ark. Agr. Exp. Sta. Bul. 123. 10. 1916.

Unexpected Influence of Blue Grass Sods in Apple Orchards

By R. D. ANTHONY, *Pennsylvania State College, State College, Pa.*

LYON and Wilson (1) at Ithaca have recently reported the failure of a system of cultivation and cover crops to maintain soil fertility during a ten-year test, while, during the same period, the use of a permanent sod added to the nitrogen of the soil. White (2) found, at the Pennsylvania Experiment Station, that the division strips in the old fertilizer plots which had been in continuous blue grass since 1867 contained 818 pounds of nitrogen in excess of that in adjoining cultivated plots which had been in a four-year rotation with one year in sod. Even when compared with plots in the rotation which had received six tons of manure biennially for 40 years, the untreated grass land contained 600 pounds of nitrogen in excess of the cultivated soil.

In fertilizer and cultural method experiments which have been under way at State College, Pennsylvania, for 21 years this failure of cultivation with cover crops to maintain fertility is now becoming very evident.

Topographic conditions in Pennsylvania make it highly desirable to keep many of the orchards in more or less permanent sod. In the older orchard regions in the northern and western parts of the state this practice has proved profitable when 5 to 8 pounds of nitrate of soda or its equivalent have been applied annually to each tree. In these portions of the State, timothy is the dominant grass. The orchards south and east of the Alleghenys are largely under 25 years of age, and it is only in recent years that any considerable proportion of the planting has been put down to permanent sod. In this region blue grass is the natural orchard cover.

For several years the Pennsylvania Experiment Station has been conducting fertilizer tests in two York Imperial orchards in the lower Cumberland Valley in Franklin County. When these tests were started both orchards were about 25 years old and had been in a thin sod of blue grass and weeds for 8 or 10 years. In one orchard the trees have received 5 or 10 pounds of nitrate of soda annually since 1921. In the summer of 1927 it was observed that the tree growth was not as satisfactory in this orchard as it had been. It was suspected that the trouble might be due to a nitrogen deficiency so, in 1928, some of the trees received 25 pounds of nitrate of soda each. In spite of this heavy application, the annual growth was only about 2 to 3 inches.

During the eight years that heavy applications of nitrate have been made in this orchard, the blue grass sod has been growing heavier each year until, by the late summer of 1928, it was one of the heaviest sods the writer has ever seen in an orchard.

The other orchard, since 1924, has received 5, 10 or 15 pounds per tree of nitrate of soda or equivalent amounts of sulphate of ammonia. Half of the orchard received an application when the first sign of growth was seen at the tip of the buds; the other half

was fertilized when the first pink showed in the blossoms. The use of this amount of nitrogen together with two applications of ground limestone and one of superphosphate brought about a rapid thickening of the sod here, also, though the blue grass in the half receiving the later fertilizations has not responded to the same extent as in the other half.

In the summer of 1928, the trees receiving the 5-pound applications began to show signs of decreasing vigor. By 1929, these trees had the typical appearance of sod trees receiving no nitrogen though the trees receiving 15 pounds were in excellent condition. During the first two years, 1924–25, the gain in yield with the trees receiving 15 pounds of fertilizer as compared to the 5-pound applications was nearly 4 bushels per tree, while for the last two years, 1928–29, it was over 7 bushels. This check to both yield and growth has been more serious in the half receiving the earliest application where the blue grass sod has become very heavy.

Two different blocks in the orchard at the Pennsylvania State College have been in blue grass sod for the past 10 years. In both, some trees have received annual applications of 5 pounds of nitrate of soda and some have had 10 pounds. During the last two years growth and yield have decreased rapidly even with the 10-pound trees.

Thus we have four cases where applications of nitrogenous fertilizers, sometimes more than double the usual commercial amounts, have failed to maintain growth or yield under conditions suggesting nitrogen starvation. Much attention has been paid to blue grass as a pasture sod. These studies (3, 4) have shown that it passes through a period of rapid growth about the time the apple is in bloom and that this growth may have a protein content as high as 20 per cent dry weight. While these conditions are very desirable in the pasture they evidently result in the orchard in too much competition for nitrogen. The lower protein content of timothy and its slower growth in spring would seem to account for the different results with these two grasses.

These adverse conditions did not develop until the sods were several years old and had become unusually heavy. It is probable that had they been turned under before becoming too heavy and then reseeded the nitrate competition would have been kept low enough to balance it economically with commercial fertilizers. It would seem that sod rotations where the sod is turned under every 3 to 6 years is a wise system of management in the blue grass area.

All of these orchards were plowed in the late fall of 1929. They will be cultivated this spring and reseeded. Their recovery under this stimulation will be studied with much interest.

Literature Cited

1. Lyon, T. L., and Wilson, B. D. Some relations of green manures to the nitrogen of a soil. Cornell Agr. Exp. Sta. Mem. 115. 1928.
2. White, J. W. Soil organic matter and manurial treatments. J. Am. Soc. Agron. 19: No. 5, 389. May 1927.
3. Ellett, W. B. Blue grass in southwestern Virginia. Va. Agr. Exp. Sta. Bul. 180. 1909.
4. Fourth–seventh Ann. Rpt. Ohio Agr. Exp. Sta. Bul. 431. 1929.

Relation of Leaf Area to Size and Quality of Apples and Pears

By J. R. MAGNESS, *U. S. D. A., Washington, D. C., and* F. L. OVERLEY, *State College of Agriculture, Pullman, Wash.*

WORK was continued by the Washington Experiment Station during the season of 1929 to determine as accurately as possible the leaf surface required to synthesize the organic foods utilized in the development of apples and pears. The work was extended to include tests on four varieties of apples and four of pears.

Methods used were similar to those described earlier. Typical branches on vigorous trees were selected as early in the season as the set of fruit could be definitely determined. Tests during 1929 were started from June 11 to June 25 on the different varieties. At this time the volume of the young fruit ranged from 10 to 20 cc. The branches selected were ringed to prevent the movement of synthesized materials into or out of the portions under test. Rings of bark about ¼ to ⅓ inch wide were removed at the points on the branch just back of the fruit and leaf areas under test, and the ringed areas immediately covered with grafting wax. All small, poorly developed leaves were removed from the branches, and fruit or leaves were removed to bring about the desired ratio of fruit to leaves. Branches from ½ to 1 inch in diameter were used. Eight to 15 fruits per branch were usually used in the tests, and 3 to 6 branches carrying each of the leaf-fruit ratios were under test on each variety.

The fruits were tagged and their circumferences measured at intervals of two weeks throughout the growing season. Only the measurements at the end of the season will be reported here. The average volumes of the fruit in cc. calculated on the basis of the fruit bearing a sphere are recorded in Table I.

The data in Table I show that there is a fairly definite correlation between number of leaves and size of fruit until at least 30 leaves per fruit are available. The increase in size of fruit is not, however, directly proportional to the increase in leaf area. In no case was fruit grown with 20 leaves twice as large as that grown with 10 leaves. Generally, the fruit grown with 30 leaves was somewhat less than double in size that grown with 10 leaves. These data would indicate that, though size of individual fruits increased with greater leaf surface per fruit, the increase in fruit volume was not proportional to the increase in leaf surface. In other words, increasing the leaf surface per fruit through thinning will decrease the total tonnage produced per tree.

The decrease in fruit produced per unit of leaf area can be explained in part as due to the greater concentration of carbohydrates in fruit grown with larger leaf area. It is also due in part to a greater storage of synthsized materials in buds and branches when the larger leaf area is available and a greater utilization of these products in wood growth. There is also a possibility that greater accumulation of synthesized materials when a large leaf area is available tends to inhibit synthesis of materials in the leaves.

TABLE I—RELATION OF AMOUNT OF FOLIAGE TO SIZE OF APPLES AND PEARS, WENATCHEE, WASHINGTON, 1929.

Variety	No. Leaves per Fruit	Total Fruits	Average Size of Fruits cc.	Approximate Number per Box
Jonathan	10	89	141.6	202
	15	86	163.2	175
	25	92	199.0	144
	40	78	216.1	132
Delicious	10	51	131.4	215
	20	72	167.4	171
	30	67	225.5	127
	40	59	227.2	126
	50	25	235.6	121
Rome	10	49	181.9	157
	20	59	241.5	118
	30	55	314.9	91
	40	56	361.1	79
	50	48	392.9	73
Winesap	10	57	122.6	233
	20	47	178.2	161
	30	44	204.6	140
	40	35	222.0	130
	50	47	213.0	134
Bartlett pears	10	37	87.4	239
	20	22	120.7	173
	30	18	148.7	140
	40	13	164.3	127
	50	12	186.8	112
Anjou pears	15	15	107.6	194
	25	30	143.6	144
	40	18	155.5	134
	60	16	215.4	97
	100	23	223.2	93
Winter Nelis pears	10	20	65.3	319
	20	18	89.2	234
	30	20	102.6	203
	40	20	118.9	176
	50	23	113.5	184

The behavior of branches ringed with different leaf areas per fruit during the season of 1928 in regard to fruit production in 1929 indicates clearly the relation between leaf surface and fruit bud formation for the following season. Table II summarizes the fruiting in 1929 of the branches treated during 1928. The results show clearly that unless a sufficient leaf area is available to develop fruit and at the same time build up an appreciable concentration of synthesized materials in the buds, fruit bud formation will not occur. At least 30 well developed leaves per fruit were required on ringed branches of Delicious before a sufficient number of fruit buds were formed to give a full crop during the following season.

Under the conditions of this test, all synthesized materials were confined in the branches on which the fruit was produced. We do not have definite data as to the percentage of the synthesized ma-

terials in normal fruit trees that are required to develop new wood and new bark tissue and to give a satisfactory storage reserve in the branches, trunk, and roots. On the basis of the increase in dry weight from season to season in a vigorous apple tree, it would seem that at least one-third of the synthesized materials from the leaves would be necessary for this purpose. One hundred pounds of dry matter in the fruit, which would be obtained from about 600 pounds of fresh fruit, would represent a heavy crop in the normal 15 to 20 year old tree. Fifty pounds of dry matter per year in new growth on such a tree would not appear to be an excessive estimate.

TABLE II—EFFECT OF 1928 LEAF AREA ON 1929 FRUIT PRODUCTION ON DELICIOUS.

Number Leaves per Fruit 1928	Number Fruit Buds 1929
10	No fruit buds formed
20	A few fruit buds—¼ to ½ crop
30	Sufficient fruit buds for heavy crop
40–50	Almost every bud was a fruit bud

Measurements of fruit trees taken in connection with fertilizer experiments have shown that there is relatively little thickening of the trunk and branches in trees bearing a very heavy crop of fruit. Apparently marked thickening of spurs, branches, and trunk occurs only when the leaf surface is sufficient to develop the fruit normally and build up a definite excess of synthesized materials in the tree. In order to secure the results obtained on ringed branches with 30 leaves per fruit it is probable that 40 to 50 leaves per fruit throughout the tree as a whole on unringed branches would be necessary.

It should also be emphasized that these results were secured in irrigated orchards and under conditions of sufficient water supply throughout the season. Preliminary results during last season indicate that with decreasing moisture supply in the soil, the stomata of apple leaves are closed through an increasing portion of the day and the leaves do not function normally in synthesizing food materials. It seems probable that the results of water shortage are very similar to results from insufficient leaf surface. Consequently, should water shortage develop through the latter part of the growing season a relatively larger leaf surface per fruit would be necessary to secure sizes similar to those reported above.

Basicly, to secure increased production in orchards it would thus appear that we must first of all increase the amount of foliage per tree or per acre. To secure regularity in production there seems to be little question, at least under Western conditions, but that the quantity of fruit produced on the trees must be sufficiently reduced through thinning to allow the development of fruit buds which result only from the accumulation of synthesized materials after the needs of the fruit have been supplied. To obtain maximum synthesis of organic foods in the leaves, sufficient moisture throughout the season to allow the leaves to function normally must be available. Thickening of buds, spurs, twigs, and trunk also depends upon an excess of synthesized materials being available after the needs of the fruit are supplied.

Seasonal Temperatures and Fruit Ripening: A Preliminary Report

By WARREN P. TUFTS, *University of California, Davis, Calif.*

LOCAL environment, more than latitude, determines the districts suitable for fruit culture in California. The lemon, one of the more tender citus fruits, is produced on a commercial scale in several instances five and six hundred miles north of the main citrus belt in southern California. Oranges in these same northern districts often ripen a month earlier than in the southern locations. Prunes in the Santa Clara Valley in close proximity to the ocean ripen two or three weeks earlier than the same varieties in the inland Sacramento Valley some two hundred miles to the north; the contrary is true with apricots, the Sacramento leading the Santa Clara valley in most seasons by practically a month. Peaches have proved unprofit-

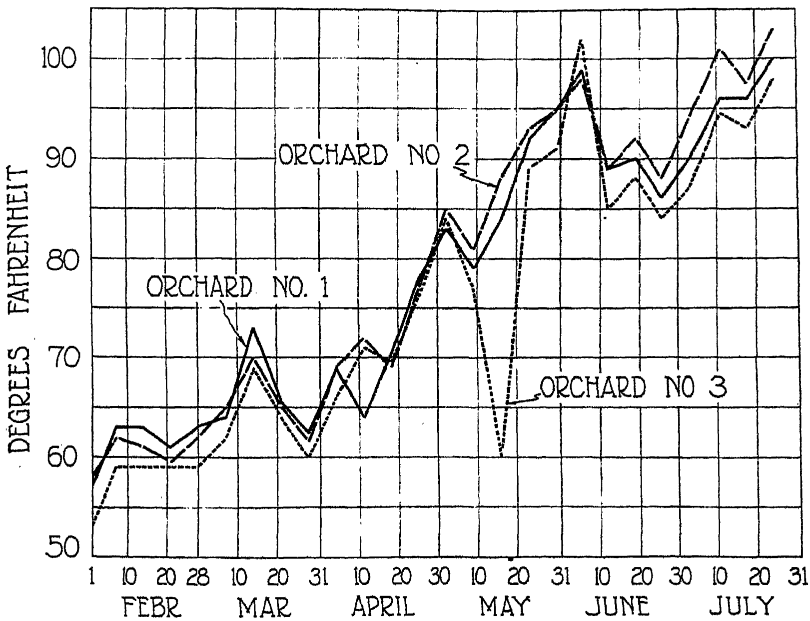


FIG. 1. Average maximum temperatures 1928.

able in several districts of southern California because the winters are not always severe enough to break the rest period, resulting in delayed foliation. It is interesting to note that these districts are located about one degree of latitude north of the center of peach production in Georgia.

The data herewith presented are part of those being collected in a study of the influence of temperature, aside from the question of early spring frosts, not only on the time of ripening but also on the

more general problem of what has been the role of temperature in determining the permanent location of profitable fruit districts.

The particular study reported here in a preliminary way, concerns itself with three apricot orchards: No. 1 on the University Farm at Davis; No. 2 located some ten miles directly west of Davis; and No. 3, four miles west of orchard No. 2. All three orchards are located on the same general soil type and are on the valley floor. The difference in the elevation of these orchards does not exceed 75 feet. Orchards 2 and 3 are located to the east and west, respectively, of the town of Winters. The Sacramento Valley at this point is approximately 50 miles wide. Orchard No. 3 lies within a mile or two of the western foothills, with Orchard No. 1 some 15 or 16 miles to the east of these hills and about one-third of the way across the valley.

The area west of Winters, in which orchard No. 3 is located, is an early ripening district; that to the east of Winters, typified by orchard No. 2, is distinctly later. Usually Royal apricots ripen 6 to 8 days earlier in orchard No. 3 than in orchard No. 2 and 2 to 3 weeks earlier

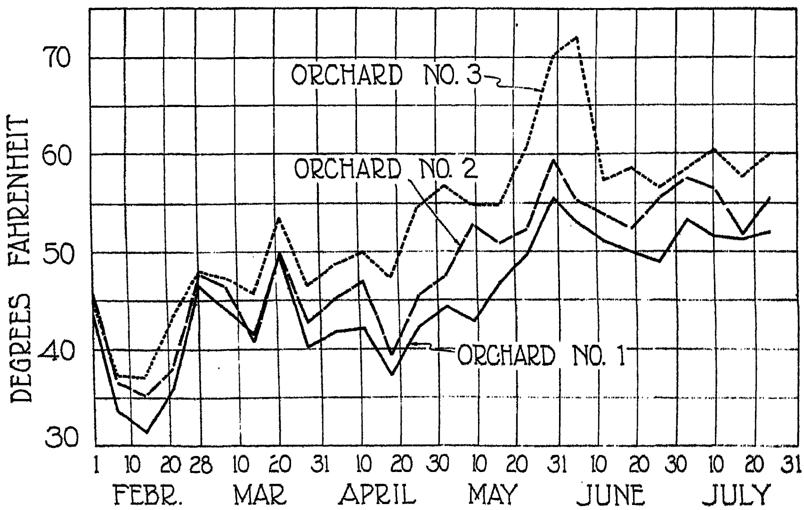


FIG. 2. Average minimum temperatures 1928.

than the same variety in orchard No. 1 (University Farm). In 1926 the apricot harvest was completed in orchard No. 3 on May 31 and in the University orchards 14 miles away, about the first of July. Apricot trees in these three orchards bloom on practically the same day.

A cool southwest wind which arises late in the afternoon greatly moderates the hot interior climate of the lower Sacramento Valley in which Davis is located. Cool summer nights prevail in this section and these have been held responsible by some for the later ripening of certain fruit crops, as the apricot. On the other hand, these same prevailing ocean breezes do not reach the upper end of the valley

and into the foothills, thus perhaps giving rise to thermal belts and early maturing districts, (Winters, for example).

To check these surmises, thermograph records have been made during the past three seasons in each of the three orchards above described. The thermographs were placed in standard U. S. Weather Bureau shelters, 4½ feet from the ground. The shelters were all uniformly exposed.

The data secured during the ripening seasons of 1927 and 1928 have been studied from several angles, such as, (1) Total number of heat units; (2) average maximum temperatures; (3) average minimum temperatures; and (4) average daily range of temperature.

To calculate heat units, 24 hours has been taken as the time unit. The temperature factor is made from four readings taken at 4 P. M., 12 Mt., 6 A. M., and 12 M. Thirty-five degrees F. has been established as the base temperature; a lower temperature is recorded

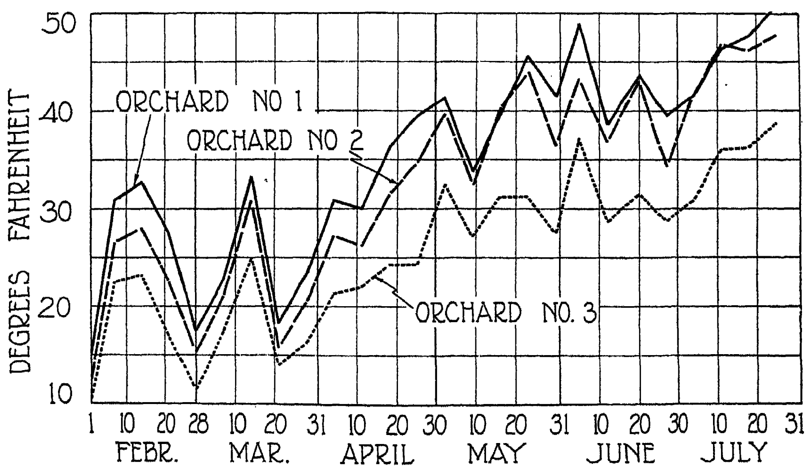


FIG. 3. Average daily range of temperature 1928.

as 0 degrees. The average of the four temperatures above 35 degrees F. is called the "Heat Units" for one 24-hour period. The temperature 35 degrees F. is purely arbitrary and possibly too low, but it probably makes no significant difference so far as this study is concerned.

A summation of the heat units, calculated as above described, for the three orchards under consideration during the period February 1 to July 31, follows:

	1927	*1928*
Orchard No. 1 (University Farm)	10,766	10,919
Orchard No. 2 (East of Winters)	11,030	11,225
Orchard No. 3 (West of Winters)	11,353	11,686

It will be noted that between February 1 and July 31, orchard No. 3 received 587 more heat units than orchard No. 1 during 1927, and 767 more during the same period in 1928. Orchard No. 2 was intermediate in total heat units as it is in time of apricot ripening.

The accompanying chart (Fig. 1) of average maximum temperatures shows orchard No. 3, which had the greatest total number of heat units, as being on the whole just a little cooler than orchards one and two. The figures for both 1927 and 1928 indicate that orchard No. 2 has in general the highest temperatures. There is, however, no great difference between any two of the three.

On the other hand, the average minimum temperatures (Fig. 2) show striking differences. Orchard No. 3 has the highest minimum temperatures and orchard No. 1 the lowest, with orchard No. 2 intermediate. This is in the same relative order as the total heat units calculated. Evidently the extra heat units enjoyed by orchard No. 3 are collected during the night and the cool southwest breezes which moderate the night temperatures at Davis do not reach as far west as Winters.

A chart (Fig. 3) of the average daily range of temperature shows that orchard No. 3 enjoys the most equable temperature, followed in turn by orchard No. 2 and orchard No. 1.

These data raise the question as to what causes the early ripening of fruit on orchard No. 3. Is the more equable temperature, the higher night temperature, or the greater total of heat units, responsible? The fruit districts of California present an unusual opportunity for studying these questions. Additional temperature stations located in other districts, where different temperature relations exist, are being established and will be utilized during the next several seasons. In all these sections altitude, soil moisture, and latitude are comparable. By the use of more stations it is hoped that it will be possible to evaluate the influence of total heat units, maximum and minimum temperatures, and daily range of temperature upon fruit development and ripening.

Some Relations of Nitrogen to Keeping Quality of Fruit

By J. H. Gourley and E. F. Hopkins, *Experiment Station, Wooster, Ohio.*

Despite some objectionable features of the widespread use of nitrogen carrying fertilizers, it is rather surprising to find a growing sentiment that simple nitrogen treatment of orchards is responsible for poor shipping quality of the fruit, internal breakdown, and other difficulties. Correspondence and verbal reports would indicate that this notion has assumed almost the proportion of propaganda in some sections.

With this situation in mind the authors have attempted a study of apple fruit grown at Wooster, Ohio, under varying treatments of fertilizers, particularly those containing nitrogen. Two orchards of five acres each, together with a third orchard of 50 trees have been laid out for this study, and fruits for analysis are gathered from plots treated as indicated in the tables of this article.

Chemical and physiological investigations made during the growing season for the past two years show some interesting effects of nitrate applications. The purpose of the studies was to determine (1) if, and to what extent, nitrogen goes into the fruit, and (2) what effect it has on the chemical composition and physiological response of the fruit. Details of the methods used will be published elsewhere. In the first season (1928) the tests included: color of fruit, growth as expressed by average diameter and weight of fruit, moisture content, total nitrogen, catalase activity, respiration, soluble pectin, and pH of the juice. In the second season (1929) these tests were supplemented by determinations on the specific gravity of the juice, total acid as malic, and reducing and total sugars. The experimental material included mature Stayman trees in sod and young Stayman, Jonathan, Wealthy, and McIntosh trees, all in cultivation.

The most striking results were obtained in the mature Stayman trees in sod. The summarized data for nitrogen analyses from these trees are given in Table I, which shows clearly that nitrate applications result in a marked increase in the nitrogen content of the fruits, whether this is expressed as the percentage on the fresh weight basis or as the grams of nitrogen per 15 fruits. In many cases this increase is well over 100 per cent. The amount of nitrogen in the fruit rose with increasing amounts of nitrate up to 8 pounds per tree, and further increase in the application did not result in a further increase in the nitrogen content of the fruit but in some cases resulted in a smaller increase. The data for 1929 show that the amount of nitrogen in the fruits from the control trees remains practically the same from July 30 on, while fruits from the nitrate-fertilized trees show marked increases thruout the season.

Results of the catalase determinations appear in Table II. Comparison of these results with those shown in Table I shows a close correlation between the catalase activity and the percentage of nitrogen in the fruit. The catalase is uniformly lowest in the control and higher in the treated plots and with few exceptions increases as the nitrogen percentage in the fruit increases. With a decrease in the per-

TABLE I—NITROGEN CONTENT OF APPLES FROM MATURE STAYMAN TREES IN SOD

Row and Tree	Treatment lbs. $NaNO_3$ per Tree*	7-31-28		9-6-28		7-9-29		7-30-29		8-12-29		9-5-29	
		Per cent N	Gms. N per 15 Fruits	Per cent N	Gms. N per 15 Fruits	Per cent N	Gms. N per 15 Fruits	Per cent N	Gms. N per 15 Fruits	Per cent N	Gms. N per 15 Fruits	Per cent N	Gms. N per 15 Fruits
H	None	.0339	.2231	.0192	.2542	.0350	.1827	.0311	.2747	.0275	.3070	.0217	.3016
A	1¾	.0308	.1979	.0234	.3673	.0439	.0546	.0338	.3434	.0309	.3706	.0232	.4566
E2	6	.0444	.3422	.0297	.5043	.0470	.3083	.0449	.4881	.0469	.5920	.0323	.6105
E3	8	.0505	.3829	.0297	.5159	.0764	.4309	.0481	.4868	.0581	.6863	.0363	.7078
E4	12	.0428	.3931	.2905	.5364	.0593	.3920	.0440	.5162	.0480	.6896	.0412	.8158
E5	14	.0414	.3457	.0260	.5182	.0659	.3941	.0418	.4677	.0483	.0363	.6892	.6844

*Chilean nitrate of soda.

centage of nitrogen for the larger nitrate applications there is a corresponding drop in the catalase activity. This furnishes an interesting confirmation of the nitrogen analyses, since in the work of Heinicke on leaves catalase activity rose with increased nitrogen.

TABLE II—CATALASE ACTIVITY OF FRUIT FROM MATURE STAYMAN TREES IN SOD

Row and Tree	Treatment (lbs. $NaNO_3$ per Tree)	Cubic Centimeters O_2 in 5 Minutes						Average (1929)
		1928		1929				
		7-31	9-6	7-9	7-30	8-12	9-5	
H	None	1.64	2.90	1.39	1.51	1.78	1.41	1.52
A	1¾	2.56	4.75	2.04	2.46	3.79	2.29	2.64
E2	6	3.20	5.50	2.66	4.75	5.23	3.15	3.945
E3	8	3.47	5.40	3.78	3.90	4.54	3.60	3.956
E4	12	2.15	4.64	3.23	4.18	4.30	3.28	3.75
E5	14	2.34	3.60	3.21	2.98	3.67	2.45	3.08

The percentages of moisture in the fruit are given in Table III. Though the results of moisture determinations are not so striking as those for catalase, there is evidently a correlation between the moisture content of the fruit and the nitrate treatment. This is brought out best in the average percentages for the 1929 season. The control is lowest and with increasing nitrate there is a gradual increase in the percentage of moisture up to 8 pounds per tree, and then with greater amounts of nitrate a slight falling off.

TABLE III—MOISTURE CONTENT OF FRUIT FROM MATURE STAYMAN TREES IN SOD

Row and Tree	Treatment (lbs. $NaNO_3$ per Tree)	Percentage of Moisture in the Fruit						Average (1929)
		1928		1929				
		7-31	9-6	7-9	7-30	8-12	9-5	
H	None	86.7	86.9	85.8	84.7	85.8	84.2	85.1
A	1¾	87.6	87.1	86.6	85.7	86.4	83.2	85.5
E2	6	88.0	87.7	87.4	86.6	86.8	84.6	86.3
E3	8	87.6	87.3	87.7	86.3	86.8	85.1	86.5
E4	12	88.2	87.6	87.7	86.9	86.7	84.1	86.3
E5	14	87.7	86.9	87.3	86.7	86.9	84.6	86.4

Observations on the coloring of the fruit showed this to be most intense and to appear first in the control, while row A was next. The higher nitrate trees showed much less and delayed coloration. Respiration determinations expressed as milligrams of CO_2 eliminated per kilogram-hour show no significant differences. Specific gravity determinations on the juice showed practically no difference in any of the plots. The hydrogen-ion concentration of the juice was also very uniform, usually varying only a few hundredths from the value, pH 3.20. The total acid in the pulp expressed as malic showed no significant differences. Altho one set of electrometric titration curves shows a definitely greater total acid and greater buffer action for the control and row A, than for the higher nitrate applications, this point will need further study. Sugar analyses have not yet been com-

pleted but the results thus far indicate that the total sugar is somewhat higher in the control and low nitrate trees.

Though the differences in young trees in cultivation were not so great as those just discussed, they were consistent and rather marked as to the nitrogen content of the fruits. Of six analyses made at different times on fruit from Jonathan trees an increase in the percentage of nitrogen of the treated over the control was shown in every instance and the grams of nitrogen per 15 fruits was greater in five of the six cases. Fruit from Stayman trees in cultivation also showed marked increase in nitrogen when the trees were fertilized for each of three samples taken in 1929. Two samples from McIntosh trees showed the same. The case of apples from Wealthy trees in cultivation is interesting. One sample taken in 1928 showed an increase of 46.0 per cent in the percentage of nitrogen in the fruit of the treated row (5¼ lbs. per tree) over the control, or calculated on the basis of total grams of nitrogen per sample, 47.2 per cent. The next season August 15, 1929, samples were taken from these same trees as follows: fifteen fruits each were selected at random from each of five trees in the control row and from each of five trees in the treated row. The results, as given in Table IV, indicate an increase in the nitrogen in the fruit which is undoubtedly significant. The average weight of fruits is also considerably greater for the treated row, while the moisture content is somewhat greater.

TABLE IV—Analyses of Fruit From Wealthy Trees in Cultivation

Row	Treatment lbs. $NaNO_3$ per Tree	Average Weight 15 Fruits in Grams	Average Per cent Moisture	Average Per cent Nitrogen	Per cent Increase of Treated Over Control	Nitrogen per 15 Fruits in Grams	Per cent Increase of Treated Over Control
18	None	2540	87.01	$.0285 \pm .0020$	——	.740	——
2	5¼	2882	87.42	$.0380 \pm .0023$	33.70	1.100	48.65

In general from these studies one may conclude that nitrates produce larger, less highly colored fruit with a higher water content, greater amount and percentage of nitrogen, and higher catalase activity. Determinations of pH, total acid, soluble pectin, and respiration showed no well-defined differences, while more analyses will be required to show the trend of soluble carbohydrates.

The ultimate interest of the orchardist is in the history of these apples in storage. Is there a difference in the keeping quality of those high in nitrogen as compared with those grown under relatively low nitrogen supply? This matter has been under observation for three seasons in a common or air-cooled storage. The data as here given indicate no significant difference in keeping quality and no treatment given has to date induced the typical breakdown of apples which has been elsewhere attributed to nitrogenous fertilizers.

Briefly, breakdown as observed in Ohio consists of an early mellowing and "mealiness" of the fruit followed by a darkening of the vascular strands, particularly the dorsal carpellary bundles and the pith region, and finally the whole cortical region is involved.

Usually the carpellary region first shows the affection. In other cases it is the region just beneath the skin which first softens.

Table V shows that fruit from trees which have been receiving from twice to nearly five times the usual amount of Chilean nitrate of soda have not decayed seriously in storage and internal breakdown has not been induced by the treatment. Elsewhere in the State internal breakdown was reported, which raises the question whether under Ohio conditions this difficulty is the direct result of nitrogenous fertilizers.

In Table VI it appears that Stayman Winesap shows no decay in common storage by April, whether the trees have received "normal" amounts or three times the normal nitrate of soda, a complete fertilizer or no treatment at all. Wealthy showed some decay by November 14 when the fruit was removed. The average of the four plots receiving "normal" nitrogen showed 10.5 per cent decay, the plot which received three times this amount of nitrogen showed 10.2 per cent, and the unfertilized plot 15.9 per cent.

TABLE V—PERCENT DECAY OR BREAKDOWN (IN APRIL) OF STAYMAN WINESAP FRUIT IN STORAGE. (FRUIT FROM TREES PLANTED 1915, GROWN IN SOD.)

1927		1928		1929	
$NaNO_3$ lbs.	Percentage Breakdown	$NaNO_3$ lbs.	Percentage Breakdown	$NaNO_3$ lbs.	Percentage Breakdown
2¾	1.6	3	4.1	3¼	0.0
		6	0.86	7	0.4
		8	0.7	10	0.5
		12	0.0	14	0.0
12	4.9	14	2.2	17½	0.0

In Table VII the storage results of another orchard are tabulated. The "normal" amount of Chilean nitrate was used in each plot except the one untreated. In some cases it was applied in April; in one it was applied in August; in another, in September; and in another, half was used in April and the balance in August. Neither with Grimes, Jonathan, nor McIntosh was there any increased decay due to treatment.

These results fail to indicate, as yet, that internal breakdown has followed any treatment employed under the conditions of these experiments.

TABLE VI—STORAGE RESULTS, 1928–29, WITH FRUIT FROM CULTIVATED ORCHARD, PLANTED 1922.

Treatment	Plot	Per cent Sound		Per cent Shriveled		Per cent Decayed		Per cent Scalded	
Stayman		April		April		April		April	
5¼ lbs. nitrate	1	84.7		0		0		15.3	
1¾ lbs. nitrate	2	67.2		10.4		0		22.4	
Complete fert.	3	68.5		0		0		31.5	
1¾ lbs. nitrate	4	84.7		1.0		0		14.3	
Nit. and Superphos.	5	85.9		1.0		1.0		12.1	
1¾ lbs. nitrate	6	94.9		0		0		5.1	
Nit. and Mur. Potash	7	83.9		5.4		0		10.7	
1¾ lbs. nitrate	8	93.2		0		0		6.8	
No fertilizer	9	91.8		2.1		0		6.1	
1¾ lbs. nitrate	10	90.9		9.1		0		0	
Average of normal N		86.2		4.1		0		9.7	
Wealthy		Oct. 17	Nov. 14	Oct. 17	Nov. 14	Oct 17	Nov. 14	Oct. 17	Nov. 14
5¼ lbs. nitrate	1	89.8	60.2	3.4	29.6	6.8	10.2	0	0
1¾ lbs. nitrate	2	91.9	69.8	2.3	16.3	5.8	13.9	0	0
Complete fert.	4	91.6	68.4	4.2	15.8	4.2	15.8	0	0
1¾ lbs. nitrate	4	86.8	62.8	7.8	26.4	5.4	10.8	0	0
Nit. and Superphos.	5	91.6	79.4	4.6	13.7	3.8	6.9	0	0
1¾ lbs. nitrate	6	91.3	72.4	0.8	10.2	7.9	17.4	0	0
Nit. and Mur. Potash	7	95.3	68.4	2.0	21.5	2.7	10.1	0	0
1¾ lbs. nitrate	8	85.7	62.5	14.3	37.5	0	0		0
No fertilizer	9	84.1	64.6	6.2	19.5	9.7	15.9	0	0
Average of normal N		88.9	66.9	6.3	22.6	4.8	10.5	0	0

TABLE VII—STORAGE RESULTS IN 1928–29 OF FRUIT FROM TILLED ORCHARD, PLANTED 1922.

Treatment	Plot	Per cent Sound		Per cent Shriveled		Per cent Decayed		Per cent Scalded	
Grimes		March	April	March	April	March	April	March	April
1¾ lb. April	1	91.6	71.4	4.2	9.9	1.5	5.3	2.7	13.4
Not fertilized	2	88.0	62.6	6.2	10.8	4.1	15.4	1.7	11.2
1¾ lb. April	3	87.7	69.8	1.9	4.7	1.9	2.8	8.5	22.7
1¾ lb. Aug.	4	74.1	58.5	3.7	6.7	6.7	8.1	15.5	26.7
1¾ lb. April	5	76.0	45.1	3.1	8.9	1.7	6.2	19.2	39.8
⅞ lb. Apr., ⅞ lb. Aug	6	71.5	57.7	2.9	3.6	7.3	13.9	18.3	24.8
1¾ lb. April	7	86.5	63.5	2.4	4.8	8.0	3.2	10.3	28.5
1¾ lb. Sept	8	77.6	62.7	4.5	7.4	4.5	6.0	13.4	23.9
Average of normal N		85.4	62.4	2.9	7.1	1.5	4.4	10.2	26.1
Jonathan									
1¾ lb. April	1	88.5	75.1	10.6	21.2	0.9	0.9	0.0	2.8
Not fertilized	2	83.1	73.0	15.7	23.8	1.2	1.5	0.0	1.7
1¾ lb. April	3	87.4	70.4	8.7	13.6	1.3	1.3	2.6	14.7
1¾ lb. Aug.	4	87.1	69.0	4.6	10.0	6.3	6.8	2.0	14.2
1¾ lb. April	5	85.9	67.3	10.2	15.0	1.7	2.2	2.2	15.5
½ lb. Apr., ½ lb. Aug	6	86.7	70.0	7.9	20.7	3.4	3.4	2.0	5.9
1¾ lb. April	7	91.6	82.1	4.6	8.0	2.3	2.7	1.5	7.2
1¾ lb. Sept	8	85.2	71.6	13.5	24.5	1.3	1.3	0	2.6
Average of normal N		88.4	73.7	8.5	14.4	1.6	1.8	1.6	10.0
McIntosh		Dec. 15	Jan. 15	Dec. 15	Jan. 15	Dec. 15	Jan. 15	Dec. 15	Jan. 15
1¾ lb. April	1	66.1	44.1	25.4	44.1	8.5	11.8	0	0
Not fertilized	2	38.2	17.6	44.1	64.7	17.7	17.7	0	0
1¾ lb. April	3	66.7	52.7	19.3	29.0	14.0	18.3	0	0
1¾ lb. Aug.	4	82.0	59.0	14.7	36.1	3.3	4.9	0	0
1¾ lb. April	5	30.5	23.7	57.6	63.6	11.9	12.7	0	0
½ lb. Apr., ½ lb. Aug	6	40.0	24.3	44.3	57.1	15.7	18.6	0	0
1¾ lb. April	7	68.6	41.9	23.8	48.6	7.6	9.5	0	0
1¾ lb. Sept	8	38.7	21.8	43.7	58.0	17.6	20.2	0	0
Average of normal N		58.0	40.6	31.5	46.3	10.5	13.1	0	0

The Effect of Various Potash Fertilizers on the Firmness and Keeping Quality of Fruits

By J. H. WEINBERGER, *University of Maryland, College Park, Md.*

COMPARATIVELY little study has been made of the relative keeping qualities of fruit from various fertilizer treatments. Although potash has not been shown to be beneficial to growth and yield of trees in most of the orchard fertilizer experiments in this country, many growers believe that the use of potash fertilizers will produce firmer fruits. The necessity for evidence on this point has become more important because of the recent contention that the use of nitrogen fertilizer injures the keeping quality of the fruit and that the use of potash fertilizers might offset the alleged ill effects of nitrogen. In view of the immediate practical importance of this problem, investigations were started in Maryland in 1928 to determine whether potassium-carrying fertilizers influence the firmness and keeping quality of apples, peaches and strawberries. In regard to strawberries, only conclusions are given.

Plan of Experiments and Methods

A series of orchard fertilizer experiments was laid out in different sections of the state in the various apple and peach orchards described in Table I. Various soil types and climatic conditions with several varieties of apples and peaches are thus included. Four forms of potash were used, namely, muriate of potash, sulfate of potash, sulfate of potash magnesia, and manure salts (20 per cent). All of these were used in combination with sodium nitrate and also in a complete fertilizer with sodium nitrate and acid phosphate. In a few cases plots with potash only were included. The amounts of each of the potash carriers applied per tree were varied to include what are termed half, single, and double amounts in each orchard.

The single treatment of potash on apples was 5 pounds of muriate of potash per tree, or the equivalent of other potash salts, while on peaches, 3 pounds of muriate of potash or equivalent of other carriers was the amount of single treatment per tree. Half treatment means half, and double treatment is double the single amounts. The double amounts of manure salts (a low grade potash) thus amounted to nearly 24 pounds per tree on apples and about 14 pounds per tree on peaches.

All plots received sodium nitrate as a standard orchard treatment, as shown in Table I. Several plots receiving nitrate only were included in each experimental orchard, to serve as checks against the nitrate plus potash, and the complete fertilizer plots. The complete fertilizer plots received acid phosphate at the rate of 5 pounds per tree on peaches, and 10 pounds per tree on apples, nitrate of soda as given in Table I, and single amounts of the potash carriers.

TABLE I—DESCRIPTION OF ORCHARDS USED IN THE STUDY OF THE EFFECT OF POTASSIUM FERTILIZERS ON THE KEEPING QUALITY OF FRUITS.

Orchard	Age of Tree (yrs.)	Type of Soil	Average Yield per Tree (bu.)	Average Terminal Growth (in.)	Nitrate Application (lbs.)	Remarks
Apples						
I. Stayman Winesap (Allen's, Salisbury)	18	Sandy loam	4	14	10	Crop reduced by frost
II. Rome Beauty (McCain's, Frederick)	14	Heavy clay loam	5	9	5	
III. York Imperial Tonoloway, Hancock	28	Limestone	6	7	8	Crop reduced by frost
Peaches						
IV. Elberta—Harrison's, Berlin	8	Sandy loam	3	7	2	
V. Elberta—Walker's Mt. Airy	9	Heavy clay loam	5	12	5	
VI. Elberta—Fulton's Hancock	5	Shale loam	2½	12	2	1929 summer extremely dry
VII. Belle of Georgia Allen's, Salisbury	9	Sandy loam	7	13	5	

Samples for storage tests were so selected that fruits from all the plots were on a comparable basis at the outset. The method of selection corresponded to what the grower calls "spotpicking," carried to a more refined degree. By this method, fruit of commercial maturity and color was taken from each plot on the same day. All the fruit used in a single storage test was of the same degree of maturity, of similar size and shape, similar ground color, covered with like amounts of blush, and was from trees with similar amounts of crop. By using uniform fruit only, variability was reduced to a minimum, and more reliable results were obtained with a given size of sample. All fruit taken from a given plot by the person or persons taking the sample was thoroughly mixed to eliminate the effect of personal variation. Inasmuch as no differences in size and color of fruit were observable among plots in the same orchard, a selected sample constituted a representative sample as well.

In the apple experiments, one or two bushels were taken from each of the plots and placed immediately in storage at 32 degrees F. At intervals of 4 to 6 weeks, 15 apples from each sample were pressure tested to determine the relative firmness and rate of softening, until the storage season had ended. A Magness pressure tester with a $\frac{7}{16}$-inch plunger was used, making three tests per apple on pared surfaces. As another measure of keeping quality, the number of decayed and scalded fruits in each sample was determined at the tine of each pressure test.

In the work on peaches, larger samples were employed. Two or 3 bushels of "shipping ripe" fruit from certain plots were held in open sheds until ripe. Pressure tests were made, at daily intervals, with a Blake peach tester having a $\frac{3}{16}$-inch plunger. Six tests on each of 30 peaches from each bushel constituted a pressure-test of that bushel for any given day. In the Berlin and Salisbury orchards, a duplicate sample was taken from each plot two days after the first sample, thus 4 to 6 bushels constituted the total amount of fruit taken from a given plot.

All pressure tests were made with unpeeled peaches. However, in the second sampling of the Elbertas at Berlin, tests were made at picking and during storage on both peeled and unpeeled fruit from five treatments (3 bushels per treatment) in order to determine the effect of removal of the skin upon the results of pressure tests. Thirty fruits taken at random from each bushel were pressure tested unpeeled and a like number from the same bushel were tested with the skin removed. The correlation coefficient (obtained from these 10,000 tests) between the change of firmness as measured by pressure tests of peeled fruit, and the change of firmness as measured by tests on unpeeled fruit during a three day storage period, is +0.962. This high degree of correlation between the changes in firmness, as determined by two pressure test averages, of different fruits from the same treatments shows: (1) that peeled or unpeeled fruits are equally reliable in showing the effect of fertility treatments, and (2) that the pressure tester, employing the number of peaches mentioned for a given test from any plot (90 peaches), is a safe measure of the firmness of a given lot of fruit.

Results with Apples

In 1928, samples of one bushel from each of the Stayman plots on a sandy loam (Orchard I) and from each of the York plots on a limestone soil (Orchard III) and two bushels from each of the Rome plots on a heavy clay loam (Orchard II) making a total of 67 bushels were placed in storage at 32 degrees F. for inspection and pressure tested during storage. Stayman samples were pressure tested at time of picking, Oct. 3, and on Dec. 8, Feb. 1, and March 15. York and Rome samples were pressure tested when picked, Oct. 11, and 15, respectively, and on Dec. 14, Jan. 18, March 2, and April 6.

No significant differences in firmness of these apples at time of picking were evident among samples from plots receiving any of the four potassium fertilizers used in half, single, or double amounts or nitrate only. The complete fertilizer treatments where each potassium salt in single amounts was used in combination with nitrogen and phosphorus likewise did not influence the initial firmness. Pressure tests during the storage period showed no consistent differences among the samples in rate of softening from one test to another. An interesting note in this connection is that the Rome apples from all plots softened rapidly until the middle of January (average pressure test decreased from 20.5 to 14.7 pounds), but on April 6 were just as firm as on January 18. When the storage tests

were concluded the fruit from the trees receiving nitrate only (check plots) was, within the limits of error, equally as firm as the fruit from any of the other fertilizer treatments.

Decay and scald counts, made on the same dates as pressure tests showed no marked differences among treatments, except in the Rome experiments. In this Rome orchard, results of only one season showed that fruit from trees receiving sulfate of potash, and sulfate of potash magnesia treatments had significantly less development of scald than fruit from the pot treated with nitrate only. Further data to substantiate this beneficial effect must be obtained before a great deal of emphasis may be placed upon the results.

In 1929, studies to date with York and Stayman apples in storage tests fully confirm the 1928 findings as regards firmness at time of picking, and rate of softening during the first 2½ months in storage. No Rome samples were obtained in 1929.

Results with Peaches

The results of experiments with peaches include the 1929 work only. The 1928 studies, while showing results similar to the later work are not as intensive or complete as the 1929 experiments in which over 170 bushels of peaches were used and more than 175,000 pressure tests made.

Two bushels of hard ripe peaches were selected from certain plots in the Hancock Elberta experiments (Orchard VI) and held in an open shed. Daily pressure tests were made, using 40 peaches from each bushel. No significant differences were evident in the firmness of the fruit from the various treatments at time of picking. Plots included in this test were: nitrate only; KCl, K_2SO_4, Mg $(KSO_4)_2$, and manure salts single; KCl and manure salts single; KCl and manure salts double; and complete with KCl and manure salts. Differences between the plots in rate of softening from one pressure test to another are variable, but since the curves of daily pressure test averages all have approximately the same trend, the differences are not significant.

In this test, as in other peach experiments, the fruits increased in firmness for a day or two after picking and then fell off, becoming softer with increasing rapidity as later stages of maturity were reached. The initial increase in firmness is believed to have been due to a rapid loss of moisture. While no significant differences could be found among the samples from various treatments in the pressure test at time of picking, a definite correlation was evident between the initial and the final pressure test. After removal of this correlation from the final pressure test averages by regression, the differences in the final pressure test between treatments were obtained and are given in Table II, using the check nitrogen as a basis (.0). None of the treatments in this orchard influenced the firmness of the peaches to any marked degree as measured by the pressure test at the end of the 6-day test, and from a commercial standpoint the differences are quite unimportant.

TABLE II—DIFFERENCES IN POUNDS PRESSURE TEST IN FRUIT FROM VARIOUS FERTILIZER PLOTS AT END OF STORAGE TESTS, COMPUTED ON THE BASIS OF NITROGEN—ONLY AS ZERO.

Differences are based on tests of 2 or 3 bushels per treatment, 30 peaches per bushel, 6 tests per peach with Blake Peach Tester, fruit in a ripe condition at time of testing.

Treatment		Elbertas				Belles	
		Mt. Airy	Hancock	Berlin	Berlin	Salisbury	Salisbusy
		Aug. 23–28	Aug. 22–28	Aug. 7–11	Aug. 9–13	Aug. 3–5	Aug. 5–7
$NaNO_3$				+ .40			
$NaNO_3$		.00	.00	— .08	— .25	.00	.00
$NaNO_3$				— .31	+ .25		
		(4.75)*	(4.42)*	(6.62)*	(5.33)*	(3.65)*	(4.73)*
N–KCl	single	+.34	—.16	—2.25	— .05	+.85	+.21
N–K_2SO_4	single	+.30	+.05	+ .14	+ .63	+.02	+.24
N–Mg $(KSO_4)_2$	single	+.09	—.26	—1.94	—1.10	+.44	+.38
N–Manure Salts	single	—.29	—.53	— .05	+1.25	—.83	—.02
N–KCl	double	—.01	—.28	+ .61	+1.75	+.22	+.21
N–K_2SO_4	double			+ .35	+ .43		
N–Mg $(KSO_4)_2$	double			+ .66	+2.20		
N–Manure Salts	double	—.31	—.74				
N–P–KCl	single	—.09	—.35	— .47		+.74	—.11
N–P–K_2SO_4	single			+ .43			
N–P–Mg$(KSO_4)_2$	single			— .80			
N–P–Manure Salts	single	—.03	—.37	— .57	+2.42		
KCl	double	+.02					
K_2SO_4	double	+.05					

*Note: Figures in parentheses are actual pressure test averages.

Three one-bushel samples from each of the plots of the Mt. Airy Elberta orchard (Orchard V), including the same plots used in the Hancock tests, show practically the same results as regards firmness at picking time, rate of ripening during storage, and comparative firmness at end of test (Table II). The differences in these samples in the final pressure test, after removal of the effect of initial firmness, are even smaller than in the Elberta samples from the Hancock experiments. In this orchard, Auchter and Schrader (1) have reported indications of increased growth and yield from the use of muriate of potash.

In the Berlin Elberta experiments (Orchard IV), a three-bushel sample of fruit was taken from each of 14 plots on Aug. 7, and a duplicate sample of three bushels from the same plots on Aug. 9. Analysis of the pressure tests made at both picking dates show that no significant differences existed between samples from plots receiving nitrate only and any of the eight potassium plots. There were no significant differences among the potash plots themselves. Complete fertilizer, likewise, did not influence the firmness of the selected fruit as measured at time of picking. During storage all samples showed the same general trend of ripening, becoming firmer immediately after picking, and then softening rapidly. The apparently detrimental effects of muriate and sulfate of potash magnesia treatments in single amounts, compared with nitrate only (Table II) are signifi-

cant in only one of the duplicate tests. The duplicates on Aug. 13 showed no significant effects, thereby throwing doubt on the significance of the first duplicates. The fruit from trees receiving double amounts of these salts tested higher at the end of the storage test than fruit from nitrated trees only, though again differences were not significant in both of the duplicates. Thus, no differences in the firmness at picking or rate of softening after picking of these samples may be attributed to the fertilizer treatments.

Duplicate samples of 2 and 3 bushels each of shipping-ripe fruit were taken on different dates from the Salisbury Belle plots (Orchard VIII). Samples were obtained from plots receiving nitrate only, or nitrate with muriate of potash, sulfate, magnesia sulfate, or manure salts in single amounts, muriate double and muriate with phosphorus. The fruit softened so rapidly that the initial increase in firmness after picking was not evident in any of the samples, and an average decrease in firmness of over 3 pounds occurred in the last 24 hours of the three day test. The samples from various plots were equally firm at time of picking, and three days later showed such small differences in firmness (Table II) that no significant differences in keeping quality between fruit from various treatments were evident.

Results with Strawberries

Two years results* of strawberry storage tests indicate that the keeping quality of strawberries, as measured by the number of decayed and soft berries developing during a holding test, is not influenced by the use of potassium fertilizers.

Conclusions

So far, under various soils and climatic conditions in Maryland, the use of potassium fertilizers, whether alone, in combination with nitrogen, or with nitrogen and phosphorus, has not affected the firmness or keeping quality of apples, peaches, or strawberries. Conclusions relative to the effect of nitrogenous fertilizers on keeping quality are presented in another paper at these meetings by E. S. Degman, using fruits from another series of plots in the Tonoloway York orchard, the Salisbury Stayman Winesap orchard, and the Mt. Airy Elberta orchard. Thus any use of potash fertilizer could not be considered as corrective, or on the other hand, to have any effect in increasing firmness of fruits when used with or without other fertilizers under the soil and climatic conditions of Maryland. Further studies on the effects of potash fertilizers on fruits are being conducted, including studies on structure and chemical composition.

Acknowledgment

The writer expresses his appreciation to Doctors E. C. Auchter and A. L. Schrader who offered numerous suggestions and kindly criticisms during the course of these investigations.

Literature Cited

1. Auchter, E. C., and A. L. Schrader. A preliminary report on peach fertilizer experiments in Maryland. Proc. Amer. Soc. Hort. Sci. 26: 263. 1928.

*Work in 1928 was done by E. C. Auchter, A. L. Schrader, W. E. Whitehouse, and others.

Effect of Fertilizers on Storage Qualities of Apples

By J. R. Magness, *U. S. D. A., Washington, D. C.*, and
F. L. Overley, *Pullman, Wash.*

TESTS to determine the effect of fertilizers on yield, color, size, and storage quality of apples were started at Wenatchee, Washington, in the spring of 1927. Though the results of these tests are far from conclusive, a brief preliminary statement can be made at this time.

Jonathan trees about 18 years old and in moderate vigor were used. The soil was a medium sandy loam of moderate fertility. A permanent cover crop of alfalfa and weeds has been growing in the orchard. The alfalfa stand is variable, but not more than one-third to one-half of a full stand.

Plots have been fertilized as follows: N only, P only. K only, NP, NK, PK, and NPK. All applications were in the inorganic form, at a rate per tree of 1 pound actual N, 1 pound P_2O_5, or 2.5 pounds K_2O, as the case may be.

Records have been kept on the individual tree basis. Those on storage quality were taken as follows: At harvest time the size and color of each individual fruit in the fertilizer plots was recorded. Samples of uniform size and color were then selected from each tree and pressure tests made on 15 representative apples. One box of fruit of uniform size and color from each tree was placed in cold storage for the determination of storage quality.

There has been a wide variation in size and color of fruits from individual trees, size of fruit being affected not only by the fertilizer treatment received, but particularly by the amount of fruit set per tree. High color also generally has been associated with medium to light crops. Jonathan apples produced in the Pacific Northwest are frequently subject to physiological breakdown, which is particularly likely to occur in the larger sizes. It was felt that unless fruit of uniform size from the different plots was selected it would not be possible to determine whether this breakdown and other ripening characteristics were associated with the fertilizer treatments or simply with the size of fruit. In other words, there would be two or three variables rather than one.

Samples of fruit placed in storage have been pressure tested at intervals through the storage season and the degree of firmness of the different lots determined. The amount of physiological breakdown and decay at the end of the commercial storage season has also been determined. Under conditions of these tests, commercial loss in the storage of the fruit has been almost completely due to physiological breakdown.

On the average, there has not been an outstanding difference in yield to date on this block which could be attributed to the fertilizer treatment. Plots receiving nitrogen have yielded slightly better than those which have not, but yield has been fairly uniform in the different plots.

Individual trees have tended to alternate in production, high yields having been followed by low yields, and these by high yields. On the average, low yielding trees have given poorer storage fruit.

The average color at harvest time has been somewhat lower in the plots receiving nitrogen than in those which have not received nitrogen. In 1928, for example, the average color of all the fruit from the plots receiving nitrogen was 65 per cent solid red; the average color on the plots receiving no nitrogen was 76 per cent. The average fruit from all trees receiving P_2O_5 was 74 per cent solid red, while fruit from all trees receiving K_2O averaged 72 per cent solid red.

There has been no significant variation in the rate of softening as measured by the pressure test which could be attributed to fertilizer treatment. Average softening of the apples from the 12 trees receiving N, P_2O_5, and K_2O, either alone or in combinations, is shown in Table I.

TABLE I—EFFECT OF FERTILIZER TREATMENT ON SOFTENING OF JONATHAN APPLES—1928.

Pressure Test in Pounds			
Date	Average of All Trees Receiving.		
	N_2	P_2O_5	K_2O
September 15 (when picked)	15.6	15.4	15.9
January 14	10.7	10.9	10.8

At the end of the storage season, fruit was inspected for physiological breakdown. The 1927 crop was picked early, and practically no breakdown occurred in any lot up to March 1, the date of final inspection.

In 1928, fruit was more advanced in maturity when harvested and some breakdown developed. Again basing averages on all trees receiving a fertilizer element, the fruit from all trees receiving nitrogen showed 5.0 per cent breakdown when inspected March 14. P_2O_5 trees showed 1.75 per cent, and K_2O trees 1.25 per cent. The increased breakdown in the trees receiving nitrogen was due entirely to one tree which showed 40 per cent. This tree produced a light crop of large fruit, which was undoubtedly somewhat more mature at harvest time than other trees producing more fruit.

A more comprehensive test involving replicated plots of both Jonathan and Winesap was started in 1929. No results of these tests on storage quality are yet available.

No definite conclusions can be drawn from the results of these tests to date. Fruit receiving nitrogen has been somewhat poorer in color, and color has not been improved by adding P_2O_5 and K_2O in addition to the nitrogen. There has been to date no measurable difference in rate of softening due to fertilizer treatment. Though nitrogen fertilized trees showed more physiological breakdown in 1928, due to one very bad tree, the difference between the plots is not statistically significant.

Firmness and Keeping Quality of Fruits as Affected By Nitrogen Fertilizers

By E. S. DEGMAN, *University of Maryland, College Park, Md.*

WITH the greater use, in recent years, of nitrogenous fertilizers for increasing tree growth and fruit production, the question has arisen as to the effect of these fertilizers on the firmness of flesh and keeping quality of fruits. To obtain evidence on the above named question, experiments were started in 1927 on existing peach and apple fertilizer plots, conducted by the Horticultural Department of the University of Maryland.

Experimental plots were located in several commercial apple and peach orchards on several types of soil, varying from the light sandy soil of the Eastern Shore to the heavy, clay loam soils of central Maryland and the red shale soil of western Maryland. Varieties of apples studied included Williams, Stayman Winesap, and York Imperial, and varieties of peaches included Elberta and Belle. The fertilizer treatments included various nitrogen carriers, such as, sodium nitrate, ammonium sulphate, calcium nitrate, calurea, leunasalpeter, and urea. Sodium nitrate was also used in combination with phosphorus and potassium.

Samples of fruit from the various fertilizer plots were picked in a manner similar to that followed by the commercial grower, who carefully spot-picks his fruit. That is, fruit was picked as near as possible of uniform commercial maturity, as indicated by ground color, and it was selected for uniform size and color. In some of the orchards, the fruit in the check plots, which were very low in vigor, although well colored and mature, was smaller than that from the fertilized plots, and samples in these cases included somewhat smaller fruits. Fruit was taken only from trees which had comparable crops, except in cases of devitalized checks that were bearing small crops.

It is not to be assumed from the above statements that fruit in all the plots matured at the same time. As a rule nitrogen retarded maturity. However, the variation in ripening time of fruits within the same plot made it possible to find some fruit of a commercial stage of maturity on all the plots at one time.

A sample for pressure testing consisted of 15 apples or 30 peaches. The tester with the $\frac{7}{16}$-inch plunger, as described by Magness in U. S. D. A. Cir. 350, was used for apples, and each fruit was tested at three places equidistant around the fruit. For peaches, the Blake peach tester, described in New Jersey Cir. 212 was used. Each peach was tested with the skin on at six different places, including two tests on each cheek, one test near the suture, and one test nearly opposite the suture. All samples for testing were taken at random from the storage sample. Fruits from the various plots were pressure tested when picked and at intervals during storage.

This paper covers the results of two years work on fruit from trees which had been receiving their respective treatments for from three to seven years, under various soil and climatic conditions.

Results with Apples

1. *Williams Apples at Harrison's Orchards, Berlin, Md.* Fertilizer treatments began in 1922 on 12-year-old trees. The soil was a level sandy loam, and a system of clean cultivation and cover crops had been employed. Some nitrogen plots received 10 pounds of sodium nitrate per tree, while other plots received equivalent amounts of nitrogen in the form of ammonium sulphate. When phosphorus was used in addition to nitrogen, 10 pounds of acid phosphate were applied per tree. In 1928, the trees receiving nitrogen made from 10 to 11 inches terminal growth and yielded 6 to 8 bushels per tree, while the check trees made only 6 to 7 inches terminal growth and yielded 3 to 4 bushels of fruit per tree.

In 1928, two lots of Williams were picked for cold storage on July 28 and 31, respectively. Both lots were pressure tested when picked, placed in cold storage, and again tested on August 6 and August 23. There were no consistent differences in the pressure tests among any of the fertilizer treatments, either at the time of picking or during storage. In 1929, two lots of Williams were picked on July 11 and 15, respectively, for common storage. Both lots were tested daily or every other day until soft ripe, July 22. Again no consistent differences were noted.

Thus, in two seasons, the firmness of Williams apples at picking time and the rate of softening during storage were not affected by the fertilizer treatments.

2. *Stayman Apples at the W. F. Allen Orchards, Salisbury, Md.* Fertilizer treatments began in 1922 on 13-year-old trees on a level sandy soil. In 1928 the no-nitrogen trees were smaller, but were making nearly as good terminal growth as the nitrated tree. Plots were so arranged that some trees received 10 pounds of sodium nitrate per tree, some received 20 pounds per tree, and others received similar amounts of nitrogen in the form of ammonium sulphate. Certain plots received 10 pounds of nitrate of soda and acid phosphate at the rate of 10 pounds per tree. Other plots received a complete fertilizer.

On Oct. 2, 1928, a one-bushel sample of fruit was taken from each of these plots for cold storage. Pressure tests at the time of picking and subsequent tests at intervals during the storage period, Oct. 2 to March 15, revealed no significant differences among samples from any of the plots; the fruit showed the same firmness and rate of softening whether taken from unfertilized plots or from plots receiving 10 or 20 pounds of sodium nitrate per tree, or nitrate plus acid phosphate, or a complete fertilizer.

In 1929, duplicate samples of one bushel each, which were pressure tested at the time of picking, and again early in November and December, have shown no differences in firmness or rate of softening.

3. *Stayman Apples at Bowdler's Orchard, Olney, Md.* Fertilizer treatments began in 1926 on 16-year-old trees. The orchard was not cultivated and the soil was a clay loam of medium fertility. Some plots received eight pounds of sodium nitrate per tree, while others received equivalent amounts of nitrogen in the form of various other nitrogen carriers.

In 1928, the no-nitrogen trees were small, in a poorly vegetative condition with sparse foliage, and yielded about three bushels per tree, while the nitrated trees were making a vigorous growth with large, dark-green leaves and yielding 9 to 10 bushels per tree. The trees in this orchard had responded markedly to the applications of nitrogen, as regards growth, amount of foliage and crop. The small crop on the devitalized check trees consisted of fruit that was smaller and more highly colored than the fruit from the trees receiving nitrogen.

The fruit from the check trees tested significantly higher at the time of picking. After 6 weeks in cold storage at 36 to 40 degrees F. these differences were still apparent, but less significant, and by the end of the storage period, Feb. 22, had largely disappeared.

Although there is no significant difference among the samples at the end of the storage season, the fruits from the seven check plots had softened more in every case than the nitrated fruit. That is, the rate of softening is greater in the check than in the nitrated fruit.

4. *York (Imperial) Apples at the Green Lane Orchard, Hancock, Md.* Fertilizer treatments began in 1924 on 20-year-old trees. The soil was a shaley loam under a system of sod mulch. Nitrogen was applied at the rate of 5, 10, 15, and 20 pounds of nitrate of soda per tree, or equivalent amounts of nitrogen in the form of ammonium sulphate. The check trees, in 1928, were smaller and poorly vegetative, while the nitrogen trees were making from 10 to 15 inches terminal growth.

In 1928, fruit from the various plots was kept in cold storage at 32 degrees F. from October 10 to March 1. At the time of picking, fruit from the check plot tested slightly higher than fruit from the nitrated plots but at the end of storage the results were reversed. At this time, fruit from the nitrated plots tested higher than fruit from the check plot, the differences being significant only for the fruit from plots receiving 15 and 20 pounds of nitrate of soda per tree. The pressure tests indicate that the rate of softening was greater in the fruit from the check plots than from the nitrated plots.

Duplicate samples of fruit from all plots were taken again in 1929. Pressure tests at picking time and again in early November and December, show all samples to be approximately the same in firmness, regardless of plot treatments. Thus, to date, the results are the same as those secured last year.

5. *York Apples at the Tonoloway Orchards, Hancock, Md.* This orchard is located on the same ridge as the Green Lane Orchard. The trees are about 30 years old and are in sod mulch. Heavier pruning, fertilization and cultivation prior to the starting of the experiment made the trees in this orchard more vigorous than those at Green Lane. However, in 1927 the check trees were somewhat less vigorous than the nitrogen trees.

Some of the nitrogen plots received 8 pounds of sodium nitrate or the equivalent of this amount of nitrogen in the form of various other carriers of nitrogen, such as calcium nitrate, urea, leuna salpeter, and calurea. Other plots received ten pounds of sodium nitrate or this equivalent of other carriers. Applications of 15 and 20 pounds of sodium nitrate were used on some plots.

In 1927* fruit from the sodium nitrate plots and check plot was held in both cold and common storage. The fruit was divided into three lots, according to size, namely 2¼, 2½, and 3 inch. Pressure tests at the time of picking and again Dec. 14, Jan. 19, March 1, and April 1, revealed no difference in keeping quality or firmness of flesh among the samples. In both cold and common storage, the fruit from plots receiving 15 and 20 pounds of nitrate of soda per tree, the largest amounts of nitrogen applied, and the fruit from the check plots, showed the same firmness at the end of the season.

In 1928, fruit was again taken from the sodium nitrate plots and in addition from plots receiving various nitrogen carriers, on Oct. 11 and held in cold storage at 32 degrees F. until April 6. At picking time the fruit from all the plots tested very nearly the same. At the end of the storage season, fruit from the check plot tested from 1 to 2 pounds higher than fruit from plots receiving nitrogen. Although this difference is barely significant, the storage counts on this fruit revealed no significant differences in the amount of scald or breakdown. The fruit from the different plots appeared to be holding up equally well from a commercial standpoint.

In early October 1929, duplicate samples of one bushel each from plots at Tonoloway were placed in cold storage. These were pressure-tested when picked, and again in November and December. Thus far, the 1929 results agree with those of 1927 and 1928 from this orchard, as no significant differences have yet appeared between fruit of the plots receiving nitrogen and fruit of the check plots.

Results with Peaches

1. *Belle Peaches at the W. F. Allen Orchards, Salisbury, Md.* Fertilizer treatments began in 1922 on 6-year old trees. The soil was a sandy loam and a system of clean cultivation and cover crops was used. Nitrogen fertilizers normally resulted in greatly increased growth and yield, but these differences were less marked in 1928 due to the loss of most of the crop from frost in 1927. The nitrogen plots received either 5 or 10 pounds of sodium nitrate per tree or the equivalent of this amount of nitrogen as ammonium sulphate.

On August 3 and August 6, 1929, duplicate samples were taken from these plots and held in common storage for 5 days. Fruit from the plot receiving 5 pounds of nitrate of soda per tree, in both pickings tested slightly higher at the beginning and a trifle lower at the end of the storage period than that from the check plot, thus showing a slightly more rapid rate of softening than the check. There were no consistent differences with any of the other plots, including the plot receiving 10 pounds of nitrate of soda per tree, which makes the difference noted between the 5 pounds of nitrate and check of questionable significance.

2. *Elberta Peaches at Walker's Orchard, Mt. Airy, Maryland.* Fertilizer treatments began when the orchard was planted in 1922. The orchard is on a heavy clay loam soil and a system of clean

*The work in 1927 was carried on by E. C. Auchter and A. L. Schrader.

cultivation is practiced. In 1928, the no-nitrogen trees averaged 2.8 bushels per tree while the nitrogen plots averaged 3.3 bushels per tree. The nitrogen trees received 5 or 10 pounds of nitrate of soda per tree or the equivalent of this amount of nitrogen in the form of ammonium sulphate.

In 1929, triplicate one-bushel samples from these plots were held in common storage for 6 days, Aug. 23 to 29. The fruit was pressure-tested when picked and at daily intervals in storage. No significant differences were noted between any of the plots. The fruit from all plots was equally firm, at the end of the storage regardless of the treatment.

Conclusions

In this work, the application of nitrogen fertilizers has caused no consistent change in the keeping quality of apples or peaches, as indicated by pressure tests and storage counts.

Under Maryland conditions, the applications of nitrogenous fertilizers do not directly influence keeping quality of fruits. However, there seems no doubt that when orchard practices, as pruning, soil management, thinning, irrigation, etc., are unwisely administered in connection with the use of nitrogen, resulting in the production of excessively large fruit, or when immature fruit is harvested, there will be a decrease in keeping quality, which is often incorrectly ascribed to the use of nitrogen.

Conclusions relative to the effect of potassium-carrying fertilizers on keeping quality, using fruits from a similar series of plots in the Berlin Williams orchard, the Salisbury Stayman Winesap and Belle orchards, the Tonoloway York orchard, and the Mt. Airy Elberta orchard are reported in another paper at these meetings by J. H. Weinberger.

Acknowledgment

The writer expresses his appreciation to Doctors E. C. Auchter and A. L. Schrader who offered numerous suggestions and kindly criticisms during the course of these investigations.

Some Growth Responses of Elberta Peach Trees to Fertilizer Treatments

By F. S. Lagassé, *University of Delaware, Newark, Dela.**

THE material used in this study consisted of 40 selected one-year-old Elberta peach trees, each of which was grown from 1910 to 1918 in a large circular concrete pit 12 feet in diameter which contained about 22.5 tons of Delaware Bay bar sand. This provision for a similar media it is felt, should be considered if criticism is given the small number of individuals used. Analysis of this sand showed it to be low in nitrogen, phosphorus, and potassium. Ample drainage was provided for each pit. The tops of the trees were pruned to two feet in length from bud and the roots were pruned back to about eight inches. The trees were then washed free from soil, air dried and the weight of each determined before being planted in the center of its allotted pit.

The trees were planted in the spring of 1910 and the different fertilizer treatments were applied to the surface of the pits soon after. This annual application, made until removal of the trees nine years later, was spread over the surface of the pit in the spring and raked into the sand. The annual amount of nitrogen, phosphorus and potassium applied is indicated by their symbols, each of which is indicative of an annual application, on an elemental basis of 50 pounds to the acre. (Ex. NPK indicates 50 pounds of each element per acre basis. This is equivalent in the case of nitrogen to 333 pounds $NaNO_3$ per acre. N_2 indicates 100 pounds of elemental nitrogen per acre, etc.). Duplication of each treatment resulted in 20 trees in duplicate, available for study. However, as the records on a number of the trees are incomplete, only 15 trees in duplicate are considered in the following data. The treatments given these trees were as follows: [(N_2PK), (N_2K), (N_2P), (N_3PK)] [(NPK), (N), (NPK_2), (NP_3K), (NP), (NPK_3)] [PK_2), (K_2), (P_2), (PK)].

Due to the limited number of trees, (2), under each treatment, it was deemed advisable for the purpose of this study to combine them into groups, as indicated above by brackets, based on the nitrogen treatment they received. These groups will be referred to from here on as, the N_2, the N, and the P and K group respectively. It is recognized that this method of comparison is not all that could be desired, for by it individuality of treatment is greatly lessened, yet the advantages gained thru an increased population seem to warrant it. The problem is thus resolved into a study of the effects of single and double amounts of nitrogen when combined with P and K, and the effects of P and K in the absence of nitrogen, on the growth and fruiting of the Elberta peach. As there were but two check trees and their average growth was in most instances a

*This experiment was planned by C. A. McCue and was under his immediate supervision. The following workers were connected with the experiment at one time or another: R. R. Pailthorp, R. A. Nehp, C. C. Wiggans, and N. L. Partridge. The author also wishes to acknowledge the advice and suggestions of Prof. G. L. Schuster of this University, with respect to the application of biometrical principles to this study.

little above that of the P and K group, they have been omitted from the data, except in Table III.

In Table I, the total weights of leaves, roots, tops, roots and tops, and fruit produced by the trees in the N_2, N, and PK groups are presented, together with the differences and the probable errors of the differences. In brief, nitrogen in combination with P and K has given very significant increases in the dry weight produced over P and K combinations in all instances. Nitrogen above the normal amounts uniformly gave increases in the dry matter produced. These increases are significant.

TABLE I—COMPARISON OF THE DRY WEIGHTS OF LEAVES, ROOTS, TOPS, AND FRUIT OF ELBERTA PEACH TREES GROWN UNDER DIFFERENT FERTILIZER TREATMENTS FROM 1910–1918—EXPRESSED IN GRAMS.

Plot Groups	Total Weight of Leaves	Difference in Weight of Leaves Produced	
*N_2	14,968	N_2—N	3,350 ± 666
N	11,618	N—PK	6,320 ± 514
PK	5,298		
	Total Weight of Roots	Difference in Weight of Roots Produced	
N_2	14,094	N_2—N	3,439 ± 551
N	10,655	N—PK	5,505 ± 531
PK	5,150		
	Total Weight of Tops	Difference in Weight of Tops Produced	
N_2	30,993	N_2—N	12,102 ± 1628
N	18,891	N—PK	11,123 ± 1068
PK	7,768		
	Total Gain in Tree Weight	Difference in Total Gain Produced	
**N_2	44,710	N_2—N	15,425 ± 2056
N	29,285	N—PK	16,664 ± 1678
PK	12,621		
	Total Weight of Fruit	Difference in Total Weight of Fruit	
***N_2	15,014	N_2—N	8,538 ± 1219
N	6,476	N—PK	4,088 ± 1204
PK	2,388		

*See text for constitution of N_2, N, and PK groupings.

**If weight of roots and tops are added, a total different from that expressed is obtained. This is because the total weight herein expressed is the difference between the weight of trees at time of digging and planting, whereas the total obtained by adding the weights of tops and roots, includes the original weights of the trees.

***The records on fruit yields are not as complete as desired, and accordingly too much weight should not be given them.

Table II presents the proportion, expressed in percentage of dry weight of, roots to top, leaf weight to root weight, leaf weight to top weight, and leaf weight to total tree weight, with the probable errors of the differences. As N is applied and then increased, the percentage of roots to tops decreases approximately 10 per cent in each case. Apparently a smaller root system in proportion to top developed as more introgen became available, even though, as shown in Table I,

an actual increase in weight of roots occurs upon the addition of nitrogen. It is suggested that this increase in the proportion of tops to roots is attributable to the more complete utilization of the carbohydrates within the trees receiving nitrogen, which results in longer terminal growth and increased diameter of spurs, branches, and trunks, and thus leaves a smaller proportion to be translocated to the roots.

TABLE II—PROPORTIONS EXPRESSED IN PERCENTAGE, OF THE DRY WEIGHTS IN GRAMS OF ROOTS TO TOPS, LEAVES TO ROOTS, LEAVES TO TOP, AND LEAVES TO TREE WEIGHT.

Average Percentage of Roots to Tops in the Several Plots		Difference in Percentage of Roots to Tops in the Several Plots	
N_2	46.5	N_2—N	—10.4±2.73
N	56.9	N—P, or K	— 9.5±3.22
P, or K	66.4	N_2—P, or K	—19.9±2.68
Average Percentage of Leaf Weight to Root Weight in the Several Plots		**Difference in Percentage of Leaf Weight to Root Weight in the Several Plots**	
N_2	110.5	N_2—N	— 5.4±6.81
N	115.9	N—P, or K	7.6±5.88
P, or K	108.3	N_2—P, or K	2.2±5.88
Average Percentage of Leaf Weight to Top Weight in the Several Plots		**Difference in Percentage of Leaf Weight to Top Weight in the Several Plots**	
N_2	45.3	N_2—N	—20.1±3.7
N	65.4	N—P, or K	— 4.8±3.42
P, or K	70.2	N_2—P, or K	—24.9±2.2
Average Percentage of Leaf Weight to Tree Weight in the Several Plots		**Difference in Percentage of Leaf Weight to Tree Weight in the Several Plots**	
N_2	34.2	N_2—N	— 8.0±1.95
N	42.2	N—P, or K	— 1.3±1.94
P, or K	43.5	N_2—P, or K	— 9.3± .328

The proportion of leaf to root weight, however, presents a different relationship, for the differences between plots are small and not significant. It would, therefore, seem that root weight at least under the conditions of this experiment is closely correlated with leaf weight or vice versa and that nutritional conditions that affected the development of one similarly affected the other so that their proportion remained practically unchanged.

In the percentage of leaf weight to weight of top produced, a considerable difference exists, especially between the N_2 and PK plots. It seems significant that in the PK plot the weight of leaves produced equalled 70 per cent of the weight of the top, whereas in the N_2 plot the weight of leaves produced was only 45 per cent of the weight of the top, even though the actual weight of the leaves increased (Table I) with increased amounts of nitrogen. This seems to indicate a much greater effectiveness of the leaves on the N_2 trees in forming top growth, as compared to those on the PK trees. The difference in this respect between the N and PK plots is not great and is not supported by odds sufficiently great to be significant. The difference between the N_2 and N plots in this respect is, however, supported by significant differences as is also the difference between the N_2 and P or K plots.

The relationship of leaf weight to tree weight is about the same as that found in the proportion of weight of leaves to weight of top, altho the inclusion of root weights somewhat masks the extent of the differences observed in the case of the leaves, as would be expected from the data previously noted on their behavior.

TABLE III—AVERAGE GAIN IN GRAMS OF DRY WEIGHT OF LEAVES PRODUCED BY TREATED TREES OVER CHECK TREES (1910–1918).

Plot Nos.	Treatment	Dry Weight of Leaves in Gms.	Odds
16/30	Check	5955	
	Gains Over Untreated Plots		
10/28	N_2K	9364	212:1
17/37	N_3PK	8426	212:1
9/27	N	7757	322:1
8/25	N_2P	7056	108:1
20/38	NP_3K	6254	322:1
3/23	NPK	6170	255:1
7/24	NPK_2	6157	69.4:1
18/33	NP	4955	166:1
12/34	NPK_3	2683	108:1
13/32	PK_2	385	1.92:1
15/39	K_2	— 155	1.55:1
19/35	P_2	—1075	2499:1
6/26	PK	—1784	166:1
4/29	P	—2432	384:1
2/22	K	—2962	555:1

Table III shows the total gain in weight of leaves produced over checks by treated trees in a nine year period. Wherever nitrogen in combination with P, or K, was used, significant gain over check was made, and wherever nitrogen was omitted the check in most instances surpassed the P, or K, treated trees. These results are supported by significant odds.

In summarizing, it appears that Elberta peach trees receiving over a nine-year period from time of planting, nitrogen in combination with phosphorus and potassium, produced a greater dry weight of leaves, roots, tops, and fruit than similar trees which did not receive nitrogen. Phosphorus and potassium combinations applied to similar trees in the absence of nitrogen resulted in most instances in a decrease in the total dry weight of leaves produced over a nine year period as compared to check trees.

The dry weight of the roots of normally fed Elberta peach trees averaged about 57 per cent of the weight of the top of the tree at the end of a nine year period. Increasing the supply of available nitrogen decreased the percentage of roots to tops nearly 20 per cent.

The proportion of leaf weight to root weight was about 116 per cent and was affected in this study only slightly by changes in nutritional treatment. The probable error is indicative that the responses to treatments were negative.

The proportion of leaf weight to top weight averaged about 65 per cent. The heavier applications of nitrogen reduced the percentage to 45 from 70 in the case of trees receiving only P and K.

The proportion of leaf weight to tree weight at the end of a nine year period averaged about 42 per cent.

A Preliminary Study of the Factors Affecting the Red Color on Apples

By L. A. Fletcher, *University of Maryland, College Park, Md.*

ALTHOUGH red color is recognized as one of the principal factors in the market value of the apple fruit, little study has been attempted, until recently, of the factors influencing color development. Overholser (1) has shown that the effect of light exclusion with cloth bags varies with species; apples, except the Williams, did not develop any color under black cloth bags. Recently Magness (2) has shown that leaf area is correlated with color development in apples, which he explains on the basis of greater sugar content in the fruit with greater leaf area. The effect of thinning of apples in increasing color is thus related to leaf area as well as to increased sunlight. Soil nutrients, especially potash, have been thought to influence color, but there is practically no evidence to warrant this assumption.

The present studies, covering the past three years, were made on light exclusion, ultra-violet light, artificial feeding of the tree and fruit, defoliation and girdling, application of chemicals and fertilizer to the soil, and irrigation as affecting the red color development of apples. Macrochemical and microchemical studies were made. Much of the material presented in this brief preliminary report necessarily must be fragmentary and incomplete.

Materials and Methods

Studies were conducted in a large commercial orchard in western Maryland. The orchard was in sod mulch and had received spring and fall applications of sodium nitrate ranging from five to eight pounds total per tree for a period of five years. The trees were about 25 years old and were bearing good crops of fruit. They were given a rather careful, detailed pruning every year and were making excellent growth. In spite of excellent cultural treatments, difficulty has been experienced in obtaining highly colored fruit in this orchard. Since the orchard is located on the eastern side of a steep ridge, the trees receive comparatively little sunlight late in the afternoon. Frequent morning fogs also limit the amount of sunlight reaching the trees.

In selecting blocks for treatment great care was exercised to secure as uniform trees as possible. Varieties studied include York Imperial, Rome, Wealthy, Summer Rambo, and Williams. The relative color development under the various treatments was determined by the percentage of total area of fruit color and by its intensity. Further details of methods will be given in discussion of results.

Bagging With Various Colored Bags

It has long been observed that shaded or partly shaded fruits lack color as compared with fruits fully exposed to sunlight. When red, green, blue, purple, yellow, and transparent cellophane bags were placed around individual fruits of Rome, York Imperial, Williams,

and Summer Rambo, in 1928, only the red bags inhibited color development. Fruits which were allowed to remain under the *same* red bag longer than one month did develop color. Spectro-photometric examination of the bags showed that the original red cellophane in double thickness absorbs practically all light rays in the visible spectrum up to 581 mμ which includes the blue end of the spectrum. After one month's exposure absorption was considerably reduced, the red cellophane bags transmitting 10 per cent of the light of the blue end of the spectrum. Consequently it seemed advisable to renew the bags at monthly intervals. When this was done no color developed under the red bags. The other colored bags transmitted the complete spectrum, which explains the lack of effect of these bags.

At the time of removal of the red bags, the ground color of the bagged fruits was more yellow than on normal fruits.

In 1929 red bags only were used on Williams and Rome. One hundred fruits of Rome were bagged at monthly intervals, beginning in June. At each bagging 10 fruits of the previous bagging were exposed and a record made of color formation. With Williams, which ripened approximately July 22, only one series was bagged June 10. On July 10, bags were removed from 20 fruits. There was no color formation on the bagged fruits while the checks showed a color range from 25 to 35 per cent good color. Ten of these bagged fruits, detached from the tree and exposed to the sun for three days, showed only a trace of color. On July 13, three days after removal of bags, fruits which had not been detached from the tree showed a color development from 25 to 35 per cent and of a better quality than the checks. Six days after bag removal, the fruit left on the tree showed a color equal to the check in area (40 to 45 per cent) and of a brighter appearance, while the detached fruit showed only a slight streaking of color development and was badly shrivelled.

With Rome Beauty four series were bagged in June, July, August, and September respectively. Fruit which was bagged for one month showed, eight days after bag removal, streaks of red color equal to that of the check.

On August 10, ten fruits of the June and July series were exposed to the sun. On August 13, three days after bag removal, the fruit of the June series showed only a streaking of color, while the fruit of the July series showed a color development of 10 to 20 per cent, equal to that of the check.

On September 10, ten fruits of each series were exposed to the sun. On September 16, fruit of the June series showed only a trace of color development. On the same date, the fruit of the July series showed a color development of about 55 per cent which was superior to the check. The rate of color formation was much more rapid on the August-bagged series when this fruit was exposed to sunlight.

Chemical analyses showed the bagged fruit to be lower in acid-hydrolyzable materials, reducing sugars, and total sugars than the green side of normal fruit; but higher in acid hydrolyzable materials than the red side of the normal fruit.

In summarizing the bagging studies, it may be assumed that those rays which are absorbed by the red bags are instrumental in color

formation. These rays are in the blue end of the spectrum. The bagging studies show that the rate of color formation after removal of bags depends on the size and maturity of fruit at the time of bagging, the more immature fruit coloring more slowly after bag removal. Length of time also had an effect, since allowing the bags to remain on the fruit longer than one month retarded color formation.

Ultra-Violet Treatments

Since the blue end of the spectrum was not transmitted by red bags, some preliminary studies relative to the effect of ultra-violet light were made with the Wealthy variety. Both bagged and normal Wealthy apples, about two weeks before picking, were used. Exposure to ultra-violet light ranged from one to ten minutes. After treatment, the fruit was divided into two lots—one lot was exposed to the sun, and the other was held in the dark. Since fruit held in the dark after treatments did not develop color, further discussion deals only with fruit exposed to the sun after treatment.

The fruit which had been bagged responded readily to all exposures. Good streaking appeared three days after exposure, while unbagged green fruits reached a similar color condition only a week after treatment. At this time the bagged fruit showed 80 per cent color as against 25 per cent in unbagged green fruit which had received similar treatment. Untreated fruits showed only slight streaking.

Irrigation, Chemicals, and Fertilizers

Vigorous, productive trees of York Imperial, Wealthy, and Rome were irrigated by the flume-furrow method in 1929. The water was kept in the furrows for 12 hours twice a week, beginning July 1, and ending at harvest. Less rainfall than usual occurred during July, August, and September.

There was a marked increase in color where water was used, and the quality of this color was greatly improved. It is probable that such striking results would not be obtained during a season of more rainfall. Discussion of the possible reasons, including stomatal movement, is reserved for a later publication.

In conjunction with the usual sodium nitrate, various amounts of the following materials were applied, in the fall and spring: lime, sulphur, citric acid, ferric sulfate, ferric carbonate, manganese oxide, potassium chloride, sodium nitrate, and acid phosphate. Actual counts failed to show any difference in color, either in quantity or quality, which could be attributed to any of these treatments.

Applications of Sugar (Cerelose) to the Soil

Since carbohydrates are associated with red color production in apples it was deemed advisable to increase, if possible, the carbohydrate content of the fruit either directly or indirectly. Commencing in June and at monthly intervals thereafter, sugar in the form of "Cerelose" was applied at the rate of 10 and 20 pounds per tree, of the following varieties: York Imperial, Rome, Williams, and Summer Rambo. Three trees were used in each treatment.

Williams, which ripens about July 23 responded markedly. With this variety, trees were used which had and had not received a spring application of nitrate. Both plots had received a fall application of sodium nitrate in 1928. All trees received two applications of "Cerelose," the second on July 8. At picking time, July 23, much of the sugar of the last application could be seen on the ground around the trees.

At picking time, the fruit of each tree was segregated into color classes as follows: Zero to 25 per cent color, 25 to 50 per cent, and above 50 per cent.

TABLE I—EFFECTS OF APPLICATION OF SUGAR TO THE SOIL ON RED COLOR OF WILLIAMS' RED

Treatment	Percentage Blush				
	No. Fruits	0.25	25–50	Above 50	Remarks
20 lbs. sugar No nitrate	365	0	57	43	Blush in nature of solid blush, but rather dull.
10 lbs. sugar No nitrate	616	0	50	50	Blush in nature of streaks, all fruits showing some streaks.
Check No nitrate	179	23	43	34	Blush rather dull
20 lbs. plus nitrate	393	7.6	24.5	67	Color in nature of solid blush, very clear, bright.
10 lbs. sugar plus nitrate	203	5.9	25.1	69	Same as above.
Check sugar plus nitrate	295	11	39	50	Blush rather clear, some streaks.

Critical examination of the data in Table I shows two things—first, sugar applications increased the percentage of fruits having a high percentage of color, second, omission of spring application of sodium nitrate decreased high color as compared with trees receiving spring nitrate. The color on the nitrated trees was of better quality than on the non-nitrated trees.

The results with sugar application on the other varieties were similar to those observed with Williams. Differences in color were usually apparent two to three weeks after addition of sugar. No greater color was secured with late varieties where monthly applications were made than where only one application was made three weeks prior to picking. Fruits which received sugar applications matured about two weeks earlier than that from trees not receiving sugar.

Chemical analyses of Williams apples showed a higher content of reducing sugars in the fruits from trees treated with "cerelose" and nitrate as compared to that from trees treated with "cerelose" only. In every case except one, the addition of sugar as "cerelose" to the soil increased the reducing sugar content of the fruit. Although

the analyses show some irregularities, the results indicate that high reducing sugars are correlated with good color development.

Possible explanations of the favorable effect of the addition of "cerelose" may be ascribed to the direct intake of sugar by the roots or by its effect upon the nitrogen intake of the tree.

Microchemical and Anatomical Studies

Throughout the growing season, microchemical tests were made for glucose, starch, nitrate, cellulose, and pectins. Anatomical notes were made on region of chlorophyll development, region of anthocyanin development and general character of cellular structure. A summary of microchemical and anatomical studies follows: (1) Green fruits contain a layer of cells just beneath the epidermis, usually three or four cells deep, which give a characteristic flavonal reaction with concentrated ammonium hydroxide. In this same layer of cells, called a pigment sheath in this paper, pigmentation occurs. (2) Chlorophyll is usually in the cells underneath this pigment sheath and may be present even after the appearance of anthocyanins. (3) Starch is more abundant in the outer layer of fruit tissue early in the season, but only in a few cases were starch grains found in the pigment sheath. Starch is more abundant in the green side of an apple throughout the growing season. (4) Sugar (glucose) is more abundant in late season and may be found within the pigment sheath. It is more abundant on the red side of an apple. (5) Depth of the pigmentation varies with varieties, being only one cell deep in Williams and from four to six deep in York Imperial. (6) Cell walls are thicker on the blushed side of an apple; the thickness of cell walls diminishes as the core line is approached. (7) Anthocyanin may diffuse back into the flesh of an apple and in a few cases was found at some distance in the fibro-vascular bundles. (8) Anthocyanin was found in the petioles of leaves and in the outer cell layer of young twigs during active growing season. (9) The cells of the pigment sheath are rectangular and thick walled during the whole life of the fruit.

Defoliation and Girdling

At monthly intervals beginning June 6, and ending August 6, branches of Rome Beauty and York Imperial varieties were defoliated so as to leave 0, 20, 40, and 100 leaves per fruit. These series were run in duplicate, one series being girdled. One-half of several trees were completely defoliated, some by removing the leaves by hand, and others by spraying with hydrochloric acid, sulphuric acid, citric acid, sodium nitrate, potassium chloride, ferric sulphates, and calcium nitrate.

Complete defoliation early in the season resulted in fruit with a bronzed color. Fruit borne on branches which were completely defoliated and girdled early in the season did not develop more than streaks of color. With the Rome (girdled) 20 leaves per fruit gave characteristic color, while with York Imperial 40 leaves were required to give the characteristic color. The effect of defoliation and girdling decreased as the season advanced. Complete defoliation of

one-half trees by hand or chemicals two weeks prior to picking, increased color. Five per cent sodium nitrate and 5 per cent calcium nitrate did not injure the fruit and were the most effective defoliation agents of all the chemicals studied. Only with the Williams was there any dropping of fruit as a result of spray defoliation.

Artificial Feeding

In this work various chemicals were injected into the conducting tissues, by boring a small hole into a limb and plugging into this hole a tube leading to a supply of the chemical solution being used. York Imperial, Williams, Summer Rambo, Wealthy, and Rome Beauty were used in these investigations. Very dilute solutions of boric acid, hydrochloric acid, malic acid (inactive), glucose (cerelose), sucrose, potassium nitrate, sodium nitrate, magnesium sulfate, potassium chloride, ferric sulfate, ferric carbonate, and water were used. Injections were made three weeks prior to picking.

Boric acid in dilute concentration produced leaf injury but a marked increase in color. The flesh of such fruit was dry and had a "cheesey" consistency. Malic acid tended to retard color development. Hydrochloric acid resulted in some defoliation and an increased color development on the Williams and Rome varieties. Cerelose in dilute solution slightly increased color. Sucrose increased color only with the Rome Beauty. Sodium nitrate caused leaf injury and a lessening of color development. Ferric sulfate, magnesium sulfate, ferric carbonate, potassium nitrate, and water were without effect on the red color.

Acknowledgment

The writer expresses his appreciation to Doctors E. C. Auchter and A. Lee Schrader who offered numerous suggestions and kindly criticisms during the course of these investigations.

Literature Cited

1. Overholser, E. L. Color development and maturity of a few fruits as affected by light exclusion. Proc. Amer. Soc. Hort. Sci. 1917.
2. Magness, J. R. Observations on color development in apples. Proc. Amer. Soc. Hort. Sci. 1928.

A Comparison of Correlations of Bloom and Yield Among Nitrogen-Fertilized and Unfertilized Apple Trees

By W. A. RUTH and C. EDWARD BAKER,
University of Illinois, Urbana, Ill.

ALMOST without regard to the condition of the trees, and therefore to differences in their previous histories as individuals, the effect of nitrogen in an orchard is to produce a quite uniform deepening of color. Does the effect of nitrogen upon the complex of factors concerned in the yield-bloom relationship, some of which may be more or less independent of leaf color, produce a closer yield-bloom correlation, or is the effect only to increase the average yield? This relationship has been studied specifically in this instance with material carefully chosen for the purpose.

The work was done in the University apple orchard at Olney, Illinois, with Jonathan trees 15 years old. A part of this orchard is being used for a comparison of nitrogen fertilizers, and it was from the trees fertilized in the spring with ammonium sulfate or sodium nitrate and the unfertilized checks that the tree selections were made for this comparison. The first applications of nitrogen were made in 1928, when the buds were swelling. Ammonium sulfate was used at the rate of 4½ pounds per tree and sodium nitrate at the rate of 6 pounds. This treatment was repeated in 1929. Cultivation is limited to the early summer.

Bloom was estimated tree by tree on the percentage of a snowball bloom. To record foliage color, a set of standards was made up from oil paints to match, in diffused daylight, variously colored apple foliage. The paints were applied to ⅝ inch x 3½ inch labels which were numbered and. in use, held up at arm's length toward a tree sufficiently far away so that the color of its foliage appeared uniform. The trees were classified in this way on cloudy days early in July. This classification was made in 1929 and, since the trees might be expected to have the same grouping in 1928, the correlations for the former year are included for comparison. The predominant color of nitrogen-fertilized trees was a fairly deep green, which corresponded rather closely with Ridgway's 27'' GYm (1); among the unfertilized trees the predominant color, which was considerably lighter and yellower, although still a good green, approximated Ridgway's 31' YGm. All other trees were excluded. An additional careful selection was made for large size and an apparently healthy condition because the orchard lacks uniformity. Much of the irregularity can be attributed to a site which, although it appears superficially to be uniform, with gentle slopes, varies decidedly within distances of only a few feet. Some of the most outstanding characteristics of the soil are a low nitrogen content, a very poor subsurface drainage, due to a clay subsoil, and a pronounced resistance at the surface to wetting after drying out in the summer. In the winter and spring the soil is very wet; at that time the water table often rises to or nearly to the surface. Rye is grown in a part of the orchard. The data for the parts of the orchard with and without rye are kept separate in the following tables.

TABLE I—CORRELATIONS OF THE YIELD AND BLOOM OF TREES FERTILIZED WITH NITROGEN AND OF OTHER TREES NOT FERTILIZED. 1928.

Treatment	No. Trees	Average of		Correlation (r) of Per cent Bloom and Pounds Yield
		Bloom in Per cent	Yield in Pounds	
No fertilizer, no cover crop	22	75.4±4.4	402.3±28.9	.455±.11
Nitrogen, no cover crop	47	62.6±2.7	536.4±22.3	.549±.07
No fertilizer, rye	15	64.0±3.2	490.0±26.1	.301±.16
Nitrate, rye	18	71.7±3.3	479.2±30.4	.704±.08

TABLE II—CORRELATIONS OF THE YIELD AND BLOOM OF TREES FERTILIZED WITH NITROGEN AND OF OTHER TREES NOT FERTILIZED. 1929.

Treatment	No. Trees	Average of		Correlation (r) of Per cent Bloom and Pounds Yield
		Bloom in Per cent	Yield in Pounds	
No fertilizer, no cover crop	22	13.4±1.8	19.8± 1.7	.516± .105
Nitrogen, no cover crop	47	17.3±1.5	45.3± 4.5	.350± .09
No fertilizer, rye	15	13.3	33.7	.782± .067
Nitrate, rye	18	10.8±2.4	65.8±12.0	.801± .057

The correlations during the two years were all positive and can be considered significant. Some of the correlations were high, especially in 1929, the off year. The remaining figures show that high correlations are not invariable in the off year and that they may occur in the on year. In three comparisons out of the four to be seen in the tables the higher correlation between bloom and yield was found among the nitrogen-fertilized trees, but in only one comparison was the difference very wide. The correlation between bloom and yield appeared to be increased more by nitrogen where rye was grown than where it was not. There are a number of explanations possible, which will not be discussed because of the lack of experimental evidence for any of them. Although repeated tests might show that a higher degree of correlation commonly exists between bloom and yield among nitrogen-fertilized trees than among unfertilized trees, these figures show that the correlations themselves and the differences between them would be likely to vary from one location to another and from season to season. As a correlary, they indicate that the importance of factors other than bloom, which may exist within the tree or in its immediate environment, varies with the season, locality, and site, in spite of uniformity among the trees as far as it can be judged by a healthy condition, a fairly uniform size, and a uniform foliage color.

The correaltions indicate a closer relationship of yield to bloom among nitrogen-fertilized trees. They show the importance of variations in other factors in the complex governing the yield-bloom relationship.

LITERATURE CITED

1. RIDGWAY, ROBERT. Color Standards and Nomenclature. 1912.

The Relation of Hardiness and Maturity in the Apple*

By BYRON H. WILSON, *University of Minnesota, St. Paul, Minn.*

THE physiological means through which apple varieties differ in their ability to withstand low winter temperatures is not exactly known, though a number of studies have been made which have helped to clarify the problem. The study herein reported was made to determine whether certain characteristics such as date of leaf fall were associated with the ability of seedling varieties to withstand low winter temperatures. Leaf fall was chosen because it was thought to give an index of maturity. Early maturity has been considered by many workers to have an important bearing on the winter hardiness of a variety, though no actual data concerning this point has been published.

The study was made at the University of Minnesota Fruit Breeding Farm about 25 miles west of Minneapolis. The climate here is continental in type, the thermometer usually dropping to —20 degrees F. every winter, and every four or five years it reaches —25 degrees F. Tender varieties are injured in varying amounts every winter.

The trees studied were seven and eight years of age, differing somewhat in size, as would be expected in a planting of mixed varieties. No top-worked trees were used, unless that work had been done more than two seasons previously.

Samples of twigs were taken early in March 1928. These were packed in moist sawdust and ice which would keep the temperature from 32 degrees F to 34 degrees F. In March 1929, samples were again taken from all trees previously recorded. They were treated similarly to those of the previous season.

The amount of injury was estimated by the method devised by Beaumont and Hildreth.† In this method, an estimate of the browning of the tissues is used as an approximation of the percentage of cells killed. "Six such classes were established, and for convenience were given numerical values as: 0—no browning; 1—trace; 2—slight; 3—medium; 4—dark; 5—very dark." This estimate of browning is made in nine areas of the twig, hence, when every tissue is dark brown it is represented by a total injury score of 45, and on the other hand no injury would have a score of 0.

The measure of the time of leaf fall was necessarily arbitrary. In determining the time of leaf fall, the amount of foliage persisting on a given date was estimated in per cent of the estimated normal for the tree in full leaf. The leaf fall estimates were made twice following the 1927 season and averaged, the estimate being made in March 1928. In the second season they were made on Oct. 14, Oct. 24, Nov. 11, and Dec. 5. The estimates of Oct. 14 were not considered reliable as very few leaves had then fallen, making it practically impossible to draw fine enough distinctions. By December 5, practically all the leaves had fallen from all varieties. Consequently, the data on leaf fall that were used came from the estimates made on the other two dates.

*Published with the approval of the Director as Paper No. 912 of the Journal Series of the Minnesota Agricultural Experiment Station. †Unpublished data.

The amount of winter injury was very similar for the two seasons. The coefficient of correlation between winter injury of the two seasons for the trees on the level ground was .60±.045. On the slope the correlation between the injuries of the two seasons was .73±.040. As there was a distinct correlation between winter injury of the trees for the two seasons, a study was made to determine the consistency of behavior of other characters for the two seasons, and also the relation of these characters to winter injury.

Certain varieties began to drop their leaves before the middle of October, and in the season of 1928 all the varieties had dropped all of their leaves by December 5. In the previous year, 1927, some of the leaves of most of varieties persisted throughout the winter, enabling data to be taken on them the following spring in March, 1928. The behavior of the trees in regard to leaf fall as determined in March, 1928, was related to their behavior in the following October and November. As shown in Table I, the correlation coefficients are significant, and there is little difference between the trees located on the slope and those located on the level ground. There were small but significantly higher correlations between the March and November leaf fall estimates (level, .62±.043, slope .56±.058) than between the March and October leaf fall estimates (level .41±.058, slope .44±.069); although the correlations between leaf fall of October and November (level, .63±.042, slope .75±.036) were relataively high. The higher correlation obtained between the leaf fall of March and November is of some significance in the light of the relationship found to exist between leaf fall and winter injury as it tends to indicate that their later determinations are the most valuable.

TABLE I—CORRELATIONS BETWEEN THE PER CENT OF LEAVES PERSISTING AT VARIOUS TIMES.

		Oct. 1928	Nov. 1928
March 1928	Level	.41±.058	.62±.043
	Slope	.44±.069	.56±.058
October 1928	Level		.63±.042
	Slope		.76±.036

The estimates of persistent leaves were found to have a wide range of relationship with winter injury. The correlations between winter injury of 1927–1928 and leaves persisting on the trees in March were .52±.051 on level ground and .59±.056 on the slope. These show a distinct positive relationship which, however, is not found in the following season, when the correlations between winter injury and per cent of persistent leaves was found to be much lower. It will be seen from Table II that there was no significant correlation between injury during the winter of 1928–1929 and the number of persistent leaves in either October or November of the previous autumn.

That there is a real difference between the two seasons may be shown by comparing the correlations between winter injury and

leaf fall of the first season with those of the second season. (Table III.) The difference between the correlations, using the trees on the level, was 4.31 times the probable error while the difference for the trees on the slope was 3.99 times the probable error. These differences

TABLE II—RELATIONSHIP BETWEEN THE PER CENT OF PERSISTENT LEAVES IN THE AUTUMN OF 1928, AND THE INJURY RECEIVED DURING THE FOLLOWING WINTER.

		Leaves Persisting on the Trees on	
		Oct. 21, 1928	Nov. 11, 1928
Winter injury of 1928–1929....	Level	—.01±.070	.19±.067
	Slope	.21±.081	.15±.083

TABLE III—DIFFERENCES BETWEEN THE CORRELATIONS OF WINTER INJURY AND LEAF FALL OF 1927–1928, AND OF 1928–1929.

	Level	Slope
'r' between leaves persisting in March and injury of 1927–1928....................................	.52±.051	.59±.056
'r' between leaves persisting on Nov. 11, 1928 and injury 1928–1929....................................	.19±.067	.15±.083
Difference....................................	4.31xP.E.	3.99xP.E.

are so large that the odds are very great that they represent real differences. It is probable that weather conditions caused this result, as the two seasons were markedly different, particularly in regard to temperture.

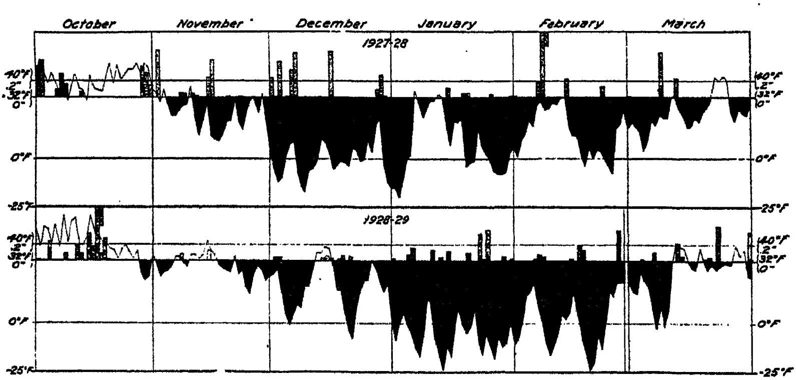


FIG. 1.—Daily precipitation and minimum temperatures for the six coldest months of 1927–1928 and of 1928–1929.

The daily minimum temperatures below 32 degrees F. are black.

The stippled areas represent rainfall. 40 degrees F. and .2 inches of rainfall are both represented by the same line.

From the meteorological data (Fig. 1) it is seen that the November and December temperatures of 1927 were much lower than those of 1928. It is suggested, to explain the differences in the correlations, that if low temperatures appear in the autumn and early winter,

there will be a fairly close relationship between percentage of leaves persisting and the amount of winter injury. However, if the late autumn temperatures are higher, the trees are able to mature their leaves, which form abscission layers and drop normally. In such a case, the correlation will probably be of little significance.

Even though such a thing may happen, it is found that correlations between leaf fall of one season and winter injury of another season are significant. Five out of six correlations showing this relationship are distinctly significant, while one is not (Table IV). Such correlations would indicate that there is a degree of constancy in the behavior of trees in different seasons.

TABLE IV—CORRELATIONS BETWEEN AMOUNT OF PERSISTENT LEAVES OF ONE SEASON, AND THE WINTER INJURY OF ANOTHER SEASON.

	Level	Slope
Winter injury of 1928–1929, correlated with persistent leaves in March, 1928	.31±.063	.35±.074
Winter injury of 1927–1928, correlated with persistent leaves on: Oct. 21, '28	.18±.068	.42±.070
Nov. 11, '28	.45±.056	.41±.070

The correlation of little significance for Oct. 21 (level .18±.068) when compared with the similar correlation for Nov. 11, 1928 (level .45±.056) showed a difference of .27±.088, which probably is significant. In Table I the correlation between leaves persisting Nov. 11, 1928, with those on March, 1928, was (level, .62±.043); and between leaves persisting on Oct. 21, 1928, with those on March, 1928, was level .41±.058. The difference between these correlations is .21±.065. These two differences, taken with other smaller differences throughout the experiment as well as the writer's experience in making leaf fall estimates when only a small porportion had fallen, lead one to conclude that estimates of leaf fall made before at least half of the leaves have fallen, are of little value.

In general, the results indicate a relationship between the amount of winter injury and the time when leaves are dropped. If life processes are interrupted by cold weather early in the autumn before late maturing varieties have dropped their leaves, the per cent of leaves persisting will give a good indication of the amount of winter injury, but if weather conditions are so favorable that all varieties are able to mature and drop their leaves before cold weather commences, then at no time in the autumn will leaf fall show any marked relationship to winter injury.

The Use of Performance Records in Laying Out a Raspberry Fertilizer Experiment*

By M. B. Hoffman, *West Virginia University, Morgantown, W. Va.*

INFORMATION on the best fertilizer practices for small fruits, particularly raspberries, is less abundant than it is with the tree fruits. Fertilizer tests that have been made have not shown consistent results. Probably no fruit is quite so sensitive to slight physical soil differences as is the raspberry. Without doubt herein lies an explanation for some of the confusing results that have been reported and an excellent reason why similar investigations have not been widely undertaken.

In the spring of 1929 studies of fertilizer requirements of red raspberries were started in a two-year-old planting of Latham at the Horticultural Farm at Morgantown, W. Va. These studies are to be continued with other varieties at different locations in the state. The Latham plantation comprised approximately one-third acre and consisted of ten rows 238 feet long and 7 feet apart. The plants had been trained to a hedge-row system. Prior to the setting of the plants an application of acid phosphate at the rate of 300 pounds per acre had been made. A cover crop of soy beans had been turned under in the fall of 1926. Other than this no fertilizer treatments had been given the planted area during its first two seasons of growth. The soil is of the De Kalb type which is rather common in northern West Virginia, and is usually regarded as medium to poor in fertility. The area is level with the exception of three rows on the south side which have a gentle down slope.

In the early spring of 1929, while the plants were still dormant, the patch was carefully studied for any variations in plant growth. The seven rows on the north side of the plantation were noticeably better in stand and cane growth than were the other three rows, which were on a slope. This indicated that the leaching away of plant food materials had been greater on the south side. The seven best rows were not as uniform in stand and growth as one would desire for fertility studies, but from a commercial standpoint this planting would be considered very uniform.

To have laid out a fertilizer experiment in this patch, with no guide except the appearance of dormant plants, would necessarily have involved much guessing, both as to the length and arrangement of plots. Because of this all fertilizer applications were postponed for one year and the plot layout of the experiment is to be based on the 1929 yield records. Since the publications of Wood and Stratton (3), and Mercer and Hall (1), the use of the probable error as a measure of reliability for field plot experiments has received much attention; however, this attention has been given to plants other than the raspberry. This study of the 1929 yield was undertaken to determine, if possible, the proper size of single-row raspberry plots and their

*Approved by the director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 82.

arrangement to reduce experimental error to practicable limits. It is realized that the yield of one season is hardly sufficient for this purpose. This paper suggests a method that will be used in obtaining information of more certain value.

Four feet at each end of each row were discarded to eliminate "border influences" and the remaining 230 feet was staked off into ten-foot plots. The ten rows furnished 230 ten-foot plots for this study, three of which were not considered because of the entire absence of plants. The total yields of crop from consecutive 10-foot row lengths were taken in ounces. These lengths were numbered consecutively up to the first row and down the next and so on to the end of the area, making the yields represent the planted area as though it were a continuous row. The yields of the 10-foot lengths or single-row plots were computed on a pounds per acre basis and these were grouped in various combinations of consecutive 10-foot plots. Plots of 10-, 20-, 30-, 40-, 50-, and 60-foot lengths were considered. Frequencies were made from their yields, and standard deviations derived (Table I).

A summary of the data in Table I shows that the populations of the frequencies range from 227 in the case of 10-foot plots to 38 in the 60-foot plots. It is interesting to note that the probable error of a single determination was reduced only 1.2 pounds per acre as a result of the increase in plot size from 10 to 60 feet. If the populations had been larger it is very likely that the distributions would have shown greater symmetry. It is intended that more definite information be added to this point in the next few years.

In selecting a plot size that would reduce experimental error to practicable limits, a comparison of the various sized plots, based on the difference between their respective standard deviations, was made. When two different plot lengths were compared and the difference between their standard deviations was three or more times its probable error it was considered that this difference was entirely significant. Using this value as a measure of reliability for increasing plot length, Fig. 1 was designed. This figure shows the row

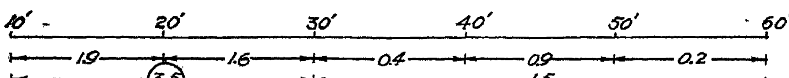


FIG. 1. Comparison of row length and variation.

lengths compared and the number of times the difference between their respective standard deviations exceed the probable error of this difference. The values considered significant are enclosed in circles. In no case did a plot length difference of 10 feet give a significant value. The first significant difference between standard deviations is found in the comparison of the 10- and 30-foot plots. A significant difference is not found again with the larger plots of this study.

This analysis seems to indicate that trustworthy results may be expected from the use of a 30-foot single-row plot. It is doubtful that this accuracy could be doubled without increasing the plot length to impracticable limits.

TABLE I—THE INFLUENCE OF PLOT SIZE ON THE REDUCTION OF EXPERIMENTAL ERROR. SUMMARIZED DATA OF YIELD RECORDS FROM LATHAM RED RASPBERRY PATCH (1929).

Classes Pounds per Acre	Length of Row 10 ft.	20 ft.	30 ft.	40 ft.	50 ft.	60 ft.
	Frequencies					
0						
200	1	2	1			
400	0	0	0			
600	3	0	1	1		
800	4	2	0	0		
1000	3	1	0	0		
1200	2	0	0	0		
1400	3	1	0	1		1
1600	3	4	1	0		1
1800	8	3	1	0	1	0
2000	5	2	3	4	3	0
2200	13	7	4	4	2	3
2400	13	4	8	3	8	3
2600	13	7	4	4	2	3
2800	13	7	6	5	2	2
3000	10	8	6	1	1	3
3200	15	5	0	3	3	2
3400	14	9	3	5	3	3
3600	19	9	11	6	4	3
3800	9	9	5	2	2	3
4000	12	2	1	5	6	3
4200	13	11	5	4	1	1
4400	8	8	4	2	1	3
4600	6	3	5	2	4	3
4800	6	1	4	3	2	0
5000	7	3	2	0	1	1
5200	5	3	1	2		
5400	6	2				
5600	6	1				
5800	2	1				
6000	3					
6200	1					
6400	1					
n.	227	115	76	57	46	38
M±Em.	3400.13±.28	3400.43±.35	3400.40±.40	3400.43±.44	3400.40±.44	3400.39±.48
Efd².	9143	3768	2035	1381	953	749
O±Eo.	6.3±.19	5.72±.25	5.17±.28	4.92±.31	4.5±.31	4.44±.34
Es.	4.24	3.85	3.48	3.31	3.03	2.99

Plot Layout of Fertilizer Experiment

Many methods have been offered for the arrangement of plots in laying out field experiments. The choice of a method should depend on several factors, such as soil, kind of plants, nature of experiment, etc. Since the 1929 yield data taken for the study of plot size were available, it was used in planning plot arrangement. If it be assumed from the first section of this paper that a single-row plot 30 feet long is the minimum size that should be used in a fertility study, then it is apparent that a 50-foot plot will reduce the experimental error to practicable limits and at the same time be the most convenient length to use in this area. Each row was divided into four 50-foot plots with a 10-foot length intervening between each two plots. The ten rows furnished 40 plots. The mean yield in pounds per acre was calculated for the forty 50-foot plots. The deivation from this mean yield was then found for each plot. When grouped there were 20 negative and 20 positive deviations. The blocks with negative deviations were then grouped according to the amount of deviation. The following group limits were used: 0 to —55; —56 to —110, and —111 to -165. Six plots fell in each group and two plots were discarded because of very low yields which placed them beyond the —165 limit of the third group. The 20 plots with positive deviations were grouped in the same way. As would be expected, the same proportional differences in yield occurred on the positive side of the mean as on the negative side. Six plots fell in each group and the yields of two plots were so high that they were discarded.

These calculations have resulted in the division of 36 plots into 6 groups of 6 plots each, based on previous yield records. It is intended that six fertilizer treatments be included in this experiment and each treatment replicated five times. One of each of the treatments will be applied to each group rather than devote an entire group to a single treatment. With this arrangement the results from any one treatment can be compared with the results from any other treatment and the data will have been taken from plants that were practically identical in vigor before treatments were applied. For convenience of explanation, let the letters A to F, inclusive, represent the six treatments. If some simple form of terminology be substituted for the groups, the following groups and treatments in each present themselves:

(Group) Based on 1929 Yields	Treatments					
—111 to —165 Low	A-1	B-1	C-1	D-1	E-1	F-1
—56 to —110 Medium low	A-2	B-2	C-2	D-2	E-2	F-2
0 to —55 Slightly below mean	A-3	B-3	C-3	D-3	E-3	F-3
Mean						
0 to +55 Slightly above mean	A-4	B-4	C-4	D-4	E-4	F-4
+56 to +110 Medium high	A-5	B-5	C-5	D-5	E-5	F-5
+110 to +165 High	A-6	B-6	C-6	D-6	E-6	F-6

The numerical figures accompanying the letters do not mean any difference in treatment but merely the group to which the A, B, or C treatment was given. Of course, the arrangement of plots by such a system does not give a systematic arrangement in the field.

In analyzing all results of treatments it is thought that Student's method of odds for paired experiments can be used satisfactorily, always pairing A-1 with B-1 or E-5 with F-5, etc., as the case may be.

ACKNOWLEDGMENT

The writer expresses his appreciation of the assistance of Professors K. C. Westover and H. E. Knowlton, who made many valuable suggestions for this study and in the preparation of this paper.

LITERATURE CITED

1. MERCER, W. B., and HALL, A. D. The experimental error of field trials. Jour. Agr. Sci. 4:107–132. 1911.
2. WESTOVER, K. C. The influence of plot size and replication on experimental error in field trials with potatoes. W. Va. Agr. Exp. Sta. Tech. Bul. 189. 1924.
3. WOOD, T. B., and STRATTON, F. J. The interpretation of experimental results. Jour. Agr. Sci. 3:417. 1910.

Effect of Fall Application of Nitrogen on the Nitrogen Content of Tree and on the Color, Firmness, and Keeping Quality of Fruit

By W. A. ALDRICH, *University of Maryland, College Park, Md.*

This paper will appear as a bulletin from the Maryland Agricultural Experiment Station.

The Control of Biennial Bearing in Apples*

By H. D. HOOKER, *University of Missouri, Columbia, Mo.*

THE alternate bearing habit of York trees has been studied since 1920 at the Riverview Orchards, McBaine, Missouri. These trees stand 25 feet apart in loess soil, which is kept in sod to prevent erosion. They have been well cared for and are now 25 years old and healthy.

During the past several years attempts have been made to alter the strictly biennial bearing habit of these trees by the application of certain nitrogenous fertilizers at various times of the two years' cycle. The field experiments have been supplemented by chemical analysis of spurs and bark. In general, it has been found (1) that the popular types of quickly available fertilizers, namely, nitrate of soda and ammonium sulphate, produce essentially the same results. Spring application has given an increased set of fruit in the bearing year and more vegetative growth in the non-bearing year. The effects of fertilization early in the season are more or less marked throughout that year. They do not extend, however, to the spring of the following year. Nitrogen application in the fall, on the contrary, has a considerable residual effect next spring. Moreover, it "tends to increase the chances for starch accumulation in non-bearing spurs the following June." Hence a conclusion is drawn that it may be practicable to supplement spring application in the off year with fall application (2).

By continuing the several fertilization programs it was actually found that some of the trees that had received either nitrate of soda or sulphate of ammonia in the middle of September of the non-bearing year had become annual bearers. But because of a heavy spring frost in one of the bearing years, it was thought that the change from alternate to regular bearing could not be attributed to the fertilizer treatments alone (3). The present paper reports the effects of pruning as a supplementary factor to the fertilization program in the control of biennial bearing in apples.

Before this special pruning was given the material was in the following condition: The trees had been quite regular biennial bearers since 1920, probably longer. They had not received any particular pruning, save a light thinning of branches. They had been fertilized in the off years (1923, 1925) in the spring and in the fall, either with nitrate of soda or equivalent amounts of sulphate of ammonia. The strictly biennial bearing habit had not been altered to any marked degree.

*Prepared by request in the name of our late colleague, Dr. H. D. Hooker, and in consultation with Mr. Patterson Bain, Jr., Manager of Riverview Orchards. The diagram is Dr. Hooker's.—A. E. MURNEEK.

Following a heavy crop in 1926, this block of trees was pruned severely during the next winter. This treatment consisted of some thinning out, but primarily of heading back to wood from three to eight years old. This pruning practice was not a part of the experimental regime. It was a decision by the manager of the orchard to bring the trees into a state where they could be more easily sprayed and the crop more conveniently harvested. During the next "off year" the trees were fertilized moderately with nitrate of soda and sulphate of ammonia in the spring and again in the fall. The fertilized trees produced a conspicuous amount of growth and some water sprouts; the non-fertilized (but pruned), much less. No pruning was given in 1927–28 and no fertilizers in the spring or fall of 1928. The crop, though reduced approximately one-third by the heavy pruning, was good in 1928—a normal "on year." In the spring of 1929, nitrogen fertilizers were applied. A fair yield of fruit was produced in this "off year," when little or none was expected, as a result of pruning and fertilization, as the following table will show:

	Average Yield Per Tree
Trees pruned and fertilized in "off year"	6.7 bu.
Trees pruned only	3.5 bu.

These figures are averages based on 137 and 229 trees respectively. They show that the good performance of these Yorks in the off year—the best in their history—can be attributed in part only to the application of readily available nitrogenous fertilizers in the spring and fall of the off year. The remarkable yield is that of the pruned, but unfertilized, trees, which had hitherto yielded practically no fruit in the off year. The severe pruning administered in the winter of 1926–27 evidently was equally potent with the fertilization in bringing about these results. At this time, of course, it is difficult to predict how lasting these effects will be and what may be the future behavior of the trees. It is equally difficult to decide at present on the best pruning program of these Yorks, since the trees are rather "open" and the fertilized ones have made vigorous growth.

In conclusion it may be said that the experimental data seem to indicate that biennially bearing apple trees are deficient in nitrogen in the off year, as a result of the heavy crop of fruit of the previous season. This deficiency may be replenished by the application of nitrogenous fertilizers in the spring and the fall of the off year, resulting in more regular bearing. However when the trees, like in the present instance, have reached a considerable age and are in a crowded condition, then fertilization alone will not bring about the desired result—an increased yield in the "off year." The current evidence indicates that moderately heavy pruning, following a large crop, may be used as a supplementary practice in breaking the biennial bearing habit of some apple varieties.

The following diagram is a schematic representation of the main idea:

Amount of HEADING next winter
Amount of NITROGEN used next spring

CROP last fall

MAXIMUM ↓

AVERAGE

ZERO ↑

Fall nitrogen when there is no crop

Effect of treatment on bearing

Literature Cited

1. Hooker, H. D. Certain responses of apple trees to nitrogen application of different kinds and at different seasons. Mo. Agr. Exp. Sta. Res. Bul. 50. 1922.

2. ————. Some effects of fall application of nitrogen to apple trees. Proc. Amer. Soc. Hort. Sci., 241. 1922.

3. ————. Annual and biennial bearing in York apples. Mo. Agr. Exp. Sta. Res. Bul. 75. 1925.

Investigations of the Fruiting Habit of the Red Raspberry

By R. V. Lott, *Colorado Agricultural College, Fort Collins, Colo.*

This paper will appear as a bulletin from the Colorado Agricultural College.

The Effects of Certain Cultural Practices on the Transmission of Virus Diseases of the Potato

By T. M. McCall, *Northwest Experiment Station, Crookston, Minn.*

THE degenerate or virus diseases of the potato, in my opinion, constitute the most baffling and perplexing problem confronting the potato grower in the seed producing centers. While a great deal has been learned relative to the transmission and elimination of degenerate diseases, yet so far, the element of uncertainty predominates most all recommendations on the control of these diseases. This element of uncertainty regarding the presence of virus diseases in seed stock has been the nightmare of not only growers of seed stock but of seed certification workers ever since the seed certification work was started. We have, through the untiring efforts of a host of workers, pretty well standardized crop production practices in the leading potato sections but we have yet to solve satisfactorily the "running-out" problem in seed stock production.

The virus disease problem on potatoes, varies somewhat in the different sections of the country, depending quite largely on the varieties grown. There are three seed stock varieties of potatoes grown in northern Minnesota, namely, Early Ohio, Irish Cobbler and Bliss Triumph. The "spindle tuber" is the virus disease of greatest importance to Early Ohio and Irish Cobbler in my section, while the mosaics are of greatest importance to the Bliss Triumph. Spindle tuber and mosaics alone or in combination may be found on any of the varieties named, however, in the Red River Valley they rank in importance in the order named. It has been the writer's observation and experience that the spindle tuber disease reduces the yields of potatoes from a trace to as much as 40 per cent of the crop and in plots where seed was 100 per cent infected the losses were correspondingly greater and not only was loss appreciable in yield of crop but in selling value as well, the same results hold true for mosaic infected stock.

The uncertainty of maintaining disease free seed stocks has been a discouraging factor to many otherwise successful potato seed growers. I personally know many potato growers who have expended time and money trying to get seed stock free from the degenerate diseases and who after all of their efforts have been disappointed because of the reappearance of spindle tuber in their fields. The writer, after observing the great rapidity with which the degenerate diseases have spread through potato seed stocks, in the absence of the commonly known insect vector (potato aphid), was led to believe that other insects or agencies were responsible for the transmission of the virus troubles. I had suspicions for several years that cutting knives and cultural practices were in a measure responsible for the rapid spread of the virus troubles, however, definite tests on this problem were not started until 1927. The two things attempted in the 1927 tests at the Northwest Station were, to determine whether or not spindle tuber was transmitted by the cutting knife and whether or not the treating of the knife-infected seed piece with the common

seed treating substances would kill the infectivity of the virus. Potato tubers showing no visible symptoms of spindle tuber were used for seed in the 1927–1928 tests. The seed pieces for the check plots were cut from the tubers with sterile knives and care was taken to see that each tuber was represented in all of the lots. We improved our technique greatly in the 1929 tests by putting the test on a tuber Unit basis, using the two stem end seed pieces of each tuber for checks and the seed end pieces for the knife infections. The two stem end seed pieces were designated as A and B and the two seed end knife-infected pieces were designated as C and D. Knife infected lot D in all units was treated after infection by dipping the seed piece in acidulated corrosive sublimate for five minutes. Acidulated corrosive sublimate prepared according to the formula of Dr. J. G. Leach, of the Minnesota Station, was the only one of the four potato seed treating substances that showed even partial control in the knife-infection tests in 1927–28 and for that reason was used exclusively in the 1929 trials.

The results of the cutting knife transmission of the virus of spindle tuber were much more apparent on the Triumph variety than on the Irish Cobbler. In the Triumph variety, nineteen of the 22 infected, non-treated units developed marked spindle tuber vine and tuber symptoms, while with the Irish Cobbler only 13 of the 20 units that were knife-infected and not treated, showed vine and tuber symptoms. The contrast between the healthy and spindling plants was less marked in the Irish Cobbler than in the Triumph variety. The spindle tuber disease was transmitted to 19 of the 22 Triumph units infected and to 15 of the 20 units of the Irish Cobbler.

The results from treating the knife-infected seed were variable between the two varieties tested; in the Triumph, of the 19 units showing spindle tuber in lots C, only 11 of that number showed spindle tuber in lots D (a reduction of infection of approximately 39 per cent); in the Irish Cobbler on the other hand seed treatment failed to reduce the infection. The yield of tubers from the knife-infected Triumphs in the spindle tuber test was 40.8 per cent less than on the healthy checks; in the Irish Cobbler the total yield of tubers on C and D was practically the same as the checks, the only differences being the spindling tubers in lots C and D.

The knife transmission tests with the mosaics in 1929 will not be completed until an index reading of the different units can be had. However this much can be reported, that knife infections of mosaic on the seed piece failed to show current season symptoms on the plants. A difference in yield was noted; however an average yield of 510.44 gms per hill was obtained on the Triumph checks while the average yield from the 25 mosaic infected units was but 431.12 gms, a reduction of 15.54 per cent. The knife infected units which had been treated yielded an average of 445.4 gms per unit or 13.8 per cent less than the non-infected. It would have been difficult to positively identify late season symptoms of mosaic under the growing conditions existing, for with a clear and bright atmosphere and a hot dry season mosaics, unless of the more virulent forms, would be easily masked.

The results obtained thus far with spindle tuber corroborates the work of Goff in demonstrating quite clearly that spindle tuber as a virus disease is transmitted by the cutting knife. The application of this knowledge especially in the seed growing sections, means that quite a radical change in cutting and planting seed potatoes must be made if the grower is expected to continue in the seed certification business. I would not revolutionize the cultural practices adopted in the table stock potato producing centers but I would recommend that certified seed growers make sure that they themselves are not spreading contamination to their isolated seed plot by the use of infected cutting knives or planters which jab or stick the seed piece. Let us hope that as our knowledge of virus diseases increases that we may find substances or solutions that will kill the infectivity of the virus troubles without injury to the crop plants.

Experimental Studies of Muck Soil As Affecting Seed and Table Quality in Potatoes

By E. V. Hardenburg, *Cornell University, Ithaca, N. Y.*

ONLY within the last few years has the use of organic soils for potato production assumed sufficient importance to arouse interest in this country. Though, a little less than two per cent of our total potato acreage was planted on this class of soils in 1929, California, Minnesota, Indiana, Michigan, Wisconsin, and New York, annually grow enough potatoes on tule, peat, or muck land to bring into question the comparative value of organic and mineral soils in their relations to seed and table quality of this crop. The familiar prejudice against the eating quality of muck-grown potatoes likely developed from the fact that the poor drainage of the first organic soils used, produced soggy tubers.

The fact that most growers in the states using muck soil generally plant upland-grown seed is evidence that muck-grown potatoes are not valued for seed by muck growers. Yet the acreage of muck-grown potatoes is increasing and the crop is in demand for both table and seed purposes at a premium over upland potatoes in many sections of the country. Experimental studies designed to afford a comparison of the relations of muck and upland soils to habit of growth, yield, seed and table quality in potatoes were initiated at the Cornell Station in 1928. A brief report of some of the results obtained in 1928 and 1929 is submitted in this paper.

Plan of Experiment

To obtain information on varietal adaptation incidental to the real purpose of the experiment, six potato varieties were used, namely, Early Ohio, Irish Cobbler, Spaulding Rose No. 4, Green Mountain, White Rural and Russet Rural. With the exception of Early Ohio, which was muck-grown and contained considerable leaf-roll disease, seed of all of these varieties planted in 1928 was certified and grown on upland the year previous and was practically free from virus. Duplicate lots of seed of these varieties were planted on both muck and upland soil plots on the same farm at Marion, N. Y. The muck was deep, well drained, and well oxidized, having a high lime content and a pH of 5.9 to 6.5. The upland soil was a heavy Dunkirk silt loam distinctly acid in reaction.

In the first year of the experiment each variety was planted in two 100-hill plots on each soil type, the hills being one foot and the rows three feet apart. Data were taken on virus disease, number of stems per hill, number of tubers per hill and yield. All diseased hills were rogued at about blossoming time to reduce the amount of disease likely to occur in the following year's crop to be grown from these seed stocks. Random seed samples of each variety from each soil type were saved for planting in 1929 back onto both muck and upland soil on the same farm. Chemical analyses for starch, total nitrogen, and total dry matter in all lots were made in the spring of 1929. Similarly, both baking and boiling tests were made for a

comparison of these two soil types in their effects on culinary quality. Both chemical analyses and cooking tests were repeated on the 1929 crop in the fall of 1929.

The 1929 tests for seed quality of the 1928 grown crop were conducted on both muck and upland soil at Marion and on upland soil only at Ithaca. Seed of each variety from both soil types was planted side by side in 2-row plots of 100-hill rows, all plots being duplicated. Equivalent weights of seed of all varieties cut to 1.2 ounce pieces were planted. Fertilization and tillage procedure on the two types of soil varied in accordance with the standard practices of the region, except in reference to ridging at the last cultivation. All plots were cultivated and sprayed the same number of times and level culture was practiced.

Habit of Growth

Distinct soil types naturally affect habit of growth and yield in accordance with differences in fertility, moisture holding capacity, and soil temperature. A comparison of muck and upland soil as to the effect on incidence of virus disease, number of stems per plant, number of tubers per plant, and yield is summarized in Tables I and II for the two years of this experiment. With the exception of Early Ohio, different strains of certified seed of each variety were used in each of the two years concerned in these tables. All differences shown here are the result of current year conditions and not the result of soil or seasonal influences of the previous year.

TABLE I—Relation of Soil Type to Habit of Growth in Potatoes at Marion, New York, in 1928

(All varieties except Early Ohio grown on upland soil in 1927)

Variety	Soil Type	Total Virus Disease (Per cent)	Average Number Stems per Plant	Average Number Tubers per Plant	Average Total Yield per Acre (Bushels)	Average U. S. No. 1 Yield per Acre (Per cent)
Early Ohio	muck	55.0	1.81	5.98	273.0	89.4
	upland	76.5	1.55	3.34	156.1	86.9
Irish Cobbler	muck	7.5	2.69	8.32	462.8	91.5
	upland	7.0	3.05	7.17	431.7	95.2
Spaulding Rose 4	muck	7.5	3.31	9.93	361.1	73.9
	upland	9.0	3.44	7.01	352.7	86.8
Green Mountain	muck	2.5	3.13	9.66	418.3	83.5
	upland	0.0	3.09	6.10	374.6	29.0
White Rural	muck	2.0	2.43	6.01	323.7	91.1
	upland	6.0	2.40	4.18	229.3	91.6
Russet Rural	muck	2.5	2.55	8.38	398.3	87.2
	upland	0.0	3.03	6.17	332.5	90.6

No consistent differences in total virus disease counts or in average number of stems per plant were evident on the two soil types in either 1928 or 1929. There was, however, a consistently larger average

number of tubers per plant on the muck soil plots both years. This difference is positively correlated with a higher average total yield per acre on the muck plots in all cases. These results coincide with recent investigations which indicate that a primary function of available nitrogen is to increase tuber-set and that number of tubers per plant is directly correlated with yield. Whereas the percentage yield of U. S. No. 1 sized tubers was rather consistently higher on the upland soil plots in 1928, the opposite was equaly true in 1929:

TABLE II—RELATION OF SOIL TYPE TO HABIT OF GROWTH IN POTATOES AT MARION, NEW YORK, IN 1929

(All varieties except Early Ohio and Spaulding Rose 4 grown on upland soil in 1928)

Variety	Soil Type	Total Virus Disease (Per cent)	Average Number Stems per Plant	Average Number Tubers per Plant	Average Total Yield per Acre (Bushels)	Average U. S. No. 1 Yield per Acre (Per cent)
Early Ohio	muck	95.0	1.69	1.80	65.3	61.1
	upland	98.0	1.13	1.10	21.7	20.2
Irish Cobbler	muck	0.0	3.20	4.25	273.8	89.8
	upland	0.0	2.39	2.52	107.1	75.6
Spaulding Rose 4	muck	20.5	2.66	4.23	315.9	95.0
	upland	31.5	3.21	3.63	191.8	82.8
Green Mountain	muck	0.0	3.37	5.66	381.2	94.3
	upland	0.0	3.42	4.01	228.1	86.9
White Rural	muck	0.0	2.50	4.39	370.8	96.4
	upland	0.0	2.46	3.20	203.8	91.2
Russet Rural	muck	0.5	3.00	5.72	398.9	94.0
	upland	0.0	2.69	4.02	221.9	87.9

SPREAD OF VIRUS DISEASES

Seed quality in potatoes is markedly influenced by the incidence of such diseases as leaf roll and mosaic. Certified seed grown on muck soil in New York frequently has been criticized as unworthy because of its virus disease content. Doctor K. H. Fernow, for several years in charge of seed potato inspection in New York, may be quoted as follows: "The chances are about 2 to 1 that any given lot of certified seed from the muck will not pass the sample standard the following year, and about 4 to 1 that it will contain enough disease to make it not wholly satisfactory." Nevertheless muck-grown seed is preferred in Minnesota and several large growers in New York find a ready demand for their muck-grown Cobbler and Green Mountain certified seed.

The incidence and spread of leaf roll and mosaic in these six standard types, are compared in Table III.

The tabulations indicate a rather marked difference between varieties in susceptibility to virus infection, according to the soil type on which they were grown the previous year. In Early Ohio the amount of virus was slightly greater in the muck-grown seed in

all three tests. No significant differences were evident in Spaulding Rose 4. In Irish Cobbler, muck-grown seed produced somewhat healthier plants than did upland-grown. The difference was even more markedly in favor of muck-grown seed of Green Mountains in all three tests. On the contrary, in White Rural and Russet Rural, leaf roll was distinctly higher in plants from muck-grown seed, the difference being most marked in Russet Rural. Whether these differences denote distinct heritable variety characters, insofar as adaptation to muck soil is concerned, is a matter for further investigation.

TABLE III—1929 TEST OF MUCK AND UPLAND SEED AS GROWN AT MARION, N. Y., IN 1928

Variety	Soil Type on Which Seed Grew in 1928	Tested at Ithaca on Upland Soil*		Tested at Marion on Muck Soil*		Tested at Marion on Upland Soil*	
		Mosaic Per cent	Leaf Roll Per cent	Mosaic Per cent	Leaf Roll Per cent	Mosaic Per cent	Leaf Roll Per cent
Early Ohio	muck	2.5	26.0	0.0	93.5	0.0	94.5
	upland	0.5	18.0	0.0	90.0	0.0	93.5
Irish Cobbler	muck	1.0	27.0	1.5	79.5	0.0	76.5
	upland	1.0	45.0	0.0	84.5	0.5	82.5
Spaulding Rose 4	muck	10.0	17.5	10.0	16.5	13.0	8.5
	upland	13.5	9.0	8.5	9.0	19.5	4.0
Green Mountain	muck	0.0	16.5	1.5	8.0	9.5	8.0
	upland	12.5	17.0	2.0	27.5	19.0	23.5
White Rural	muck	0.5	22.5	0.0	14.0	0.0	16.0
	upland	0.0	3.5	0.5	4.0	0.0	6.0
Russet Rural	muck	0.0	39.5	0.0	45.0	0.5	43.0
	upland	0.0	5.5	0.5	4.5	1.0	5.5

*Average of 2 plots of 100 hills each.

YIELD AND SEED QUALITY

It is generally conceded that the ultimate measure of quality in seed potatoes is capacity to yield, altho there is a strong tendency today to put the emphasis on freedom from virus diseases. Although the latter is unquestioned in its influence on yield, this does not negate the fact that capacity to yield is a separate and distinct heritable factor. Each of the six varietal types as grown on both muck and upland soils in 1928 were planted for yield test back on to both types of soil in 1929. The nature of the two soils used at Marion, N. Y., already has been noted. The upland soil used at Ithaca is classed as Dunkirk silt loam and is very similar to the upland soil at Marion. Both total and U. S. No. 1 average yields are reported in Table IV.

Without exception, total and U. S. No. 1 yields of both White and Russet Rurals were distinctly higher from the upland-grown seed. This difference varied from 6.4 to 107.2 bushels per acre depending on the type of soil used. In these two varieties, yields are very closely correlated with the incidence of virus disease. In direct

TABLE IV.—EFFECT OF SOIL TYPE ON VALUE OF THE POTATO CROP FOR SEED

Variety	Soil Type on Which Seed Grew in 1928	1929 Test at Marion, N. Y., on				1929 Test at Ithaca on	
		Muck Soil		Upland Soil		Upland Soil	
		Total Yield per Acre (Bushels)	U. S. No. 1 Yield per Acre (Bushels)	Total Yield per Acre (Bushels)	U. S. No. 1 Yield per Acre (Bushels)	Total Yield per Acre (Bushels)	U. S. No. 1 Yield per Acre (Bushels)
Early Ohio	muck	93.3	55.9	39.7	16.4	66.6	23.0
	upland	110.0	82.9	55.3	24.3	65.9	30.9
Irish Cobbler	muck	166.8	150.3	77.2	55.3	68.5	55.3
	upland	191.6	173.2	84.9	58.3	62.0	41.8
Spaulding Rose 4	muck	320.2	296.9	221.4	197.8	120.5	102.3
	upland	345.2	322.5	216.1	182.4	118.8	95.5
Green Mountain	muck	370.9	355.6	220.7	197.4	321.9	273.3
	upland	302.1	275.9	189.0	164.1	304.9	258.9
White Rural	muck	388.5	373.4	210.1	180.1	246.8	213.6
	upland	417.2	401.4	221.8	205.5	254.1	228.1
Russet Rural	muck	346.3	328.4	205.9	182.6	236.0	211.1
	upland	448.3	435.6	218.1	189.0	326.1	288.0

contrast, the yield of Green Mountains was in all three tests distinctly higher from the muck-grown than from the upland-grown seed. These differences varied from 14.4 to 79.7 bushels per acre, the greater differences appearing on muck soil. Here too yields are very closely correlated with the incidence of disease as shown in Table III.

With the three early varieties, the results do not show any consistently marked influence of soil type on seed quality, although in Early Ohio all three tests show a trend in favor of the upland-grown seed. The small differences in yield can be accounted for by the corresponding differences in disease content. Results with Cobbler present a still different situation. Whereas the upland seed produced a crop containing somewhat more disease in all three tests, yields from the upland seed were higher on both soil types at Marion. At Ithaca, the yield difference was small but in favor of the muck-grown seed. Spaulding Rose 4 yielded better on muck soil by 25 bushels per acre when grown from upland seed. The opposite was true to a lesser extent in the tests on upland soil.

TABLE V—RELATION OF SOIL TYPE TO COMPOSITION OF POTATO TUBERS[1]

Variety	Soil Type	Starch[2] (Per cent)		Total Nitrogen[3] (Per cent)		Total Dry Matter (Per cent)	
		1928	1929	1928	1929	1928	1929
Early Ohio	muck	11.9	11.2	0.33	0.41	17.5	17.6
	upland	11.4	12.3	0.47	0.49	17.4	19.1
Irish Cobbler	muck	10.0	9.6	0.26	0.38	15.8	16.5
	upland	11.0	10.9	0.47	0.43	17.9	17.4
Spaulding Rose 4	muck	10.8	9.6	0.26	0.43	17.0	17.0
	upland	10.3	11.5	0.46	0.45	16.5	18.1
Green Mountain	muck	14.1	12.1	0.38	0.41	19.7	18.7
	upland	12.0	13.6	0.30	0.48	18.2	20.8
White Rural	muck	11.8	11.3	0.32	0.39	17.6	17.2
	upland	11.6	11.7	0.48	0.43	17.6	17.3
Russet Rural	muck	12.5	12.1	0.47	0.39	18.2	18.0
	upland	11.8	14.2	0.47	0.42	18.7	20.5

[1]Analyses by Dr. G. V. C. Houghland, Bureau of Chemistry and Soils, U. S. Dept. of Agriculture.
[2]Herles method of starch determination (saccharimeter).
[3]Standard Kehldahl method for nitrogen determination (mercury digestion).

COMPOSITION AND TABLE QUALITY

No definite relation between composition and eating quality in potatoes appears to have been determined up to this time. It is, however, generally assumed that high content of both starch and dry matter is associated with good quality in the cooked product. Effort has been made in these studies to compare muck-grown with upland-grown potatoes in both composition and table quality. The author has had the able cooperation of Dr. G. V. C. Houghland of the U. S. Department of Agriculture in analyzing the samples for starch, total nitrogen, and dry matter and of the New York State College of Home Economics in making both baking and boiling tests.

The starch, total nitrogen and dry matter contents of the six varieties as grown on muck and upland soil in 1928 and 1929 are recorded in Table V.

The analyses for 1928 are markedly inconsistent with those for 1929 even though the same methods of analyzing were employed and the potatoes were grown on immediately adjacent plots and, therefore, essentially the same soil types. In the 1928 crop, the muck-grown lots were, with the exception of the Irish Cobblers, higher in starch than those grown on upland and excepting in the Cobblers and Green Mountains, the total nitrogen content was in inverse relation to starch. Quite in contrast, the 1929 data consistently show both a higher starch and a higher nitrogen content in the upland-grown lots. But for the consistency of the 1929 data, one would question their reliability in view of the fact that most of our reported tests of potato composition show an inverse starch-nitrogen ratio.

Boiling and baking tests of lots grown both years were made according to standard methods of evaluating culinary quality. Score-card schedules in which were considered flesh color, texture, flavor, cooking time and ability to hold shape were put in the hands of a large number of students and instructors who had no previous knowledge of the conditions under which the potatoes were grown.

The 1928 cooking tests rather consistently favored the muck-grown lots of all varieties. This was true especially in respect to whiteness of flesh, both before and after cooking. Furthermore the cooked product was of better texture as measured by degree of mealiness and dryness. Several of the upland lots developed a strong or unpleasant flavor after cooking. Similar tests of the 1929 crop did not develop any consistent differences in favor of either soil type, but the data on starch, total nitrogen and dry-matter content of the 1929 crop might be expected to indicate higher quality tubers from the upland soil.

Conclusions

Among the few obvious relationships developed in these studies from a comparison of muck with upland soil are: (1) a larger number of tubers per plant on muck soil; (2) a marked difference in varietal susceptibility to the incidence and spread of virus diseases, depending on soil type; (3) total and U. S. No. 1 yields generally but not always correlated with virus disease content; (4) no definite effect of soil type on either starch and nitrogen content or starch-nitrogen ratio; and (5) no definite relation of composition to culinary quality as affected by soil type.

The Relation of Photoperiod to the Development of a Winter Forcing Radish

By R. H. Roberts, and E. F. Burk, *University of Wisconsin, Madison, Wisc.*

COMMERCIAL greenhouse men report a need for a more satisfactory variety of radish for winter forcing. The present kinds too commonly fail to root profitably in the mid-winter season, requiring too much time and developing too few marketable roots. There is too great a tendency to "go to top."

It has been reported that this plant is very responsive to photoperiod (1). Observations of two seasons show that this is true for Early Scarlet Globe. It is further very evident that different strains of this variety respond unequally to so-called length of day conditions. Some root well in short days while others develop seed stocks under this condition. The number of plants producing fleshy roots in an optimum time is also greatly affected by the amount of available nitrogen in the soil, soil moisture, and temperature. Add to this the too frequent variation in color, shape, and amount of foliage usually found and it does seem that the commercial complaint is well founded.

Different commercial strains and selections of Scarlet Globe growing at present (December) in a common soil for seven weeks, range from 7.7 to 75.9 per cent of fleshy roots and from 0.0 per cent to 69.0 per cent marketable types of roots. They show an average range in color from pink to a live scarlet. The forms also vary from turnip shaped to the especially selected olive shaped ones. The attempt is being made to secure a longer radish than the globes which tend to crack under some growing conditions. Sufficient top for easy bunching is also desired without having too many leaves. The amount of top appears to be very much a matter of strain. While this character isvery responsive to environment, as a given length of day for example, it also varies with the seed source.

A factor which complicates the early securing of the desired types is the self sterility of many plants.

This much is clear, namely, that because of the striking response of the radish to photoperiod, nitrogen nutrient, and probably, temperature, the selections of plants for seed stock of a winter forcing variety should be made under the same environmental conditions in which the commercial crop is to be grown.

Literature Cited

1. Garner, W. W., and Allard, H. A. Further studies in photoperiodism, the response of the plant to relative length of day and night. Jour. Agr. Res., 23:871. 1923.
2. Nightingale, G. T. The chemical composition of plants in relation to photoperiodic changes. Wis. Agr. Exp. Sta. Res. Bul. 74. 1927.

The Effect of Organic Materials on the Growth of Sweet Peas and Other Greenhouse Plants

By E. C. Volz and K. Post, *Iowa State College, Ames, Iowa*

In preparing this paper the authors were cognizant of the fact that they were working in unexplored fields of greenhouse soils research. The aim of this experiment is to make a comparison of mixtures of soil and available organic materials with the usual composted soil.

The compost pile method of preparing greenhouse soil for bench crops and potted plants has been in vogue since the beginning of the floral industry. Even today many of the smaller concerns depend entirely upon this system. However, the enormous expansion of some of the larger greenhouse concerns forced growers to adopt more extensive methods and cheaper preparations of bench and potting compost. Both the compost pile and the field method are too well known to require detailed description. Each method requires large quantities of animal manure and the expense involved may be quite heavy due to the gradual decrease in the available supply. Experiment station investigations indicate that commercial fertilizers can replace manure only in part. Organic matter in some form is an absolute necessity. Unfortunately not all manure substitutes are adaptable to commercial needs as the transportation cost may be a limiting factor. At present many florists are using an imported material sold under the name "Granulated Peat Moss." The wide publicity given it has aroused considerable interest in the use of native peats. If it were possible to find a material that could be mixed with the soil to produce proper conditions for plant growth and eliminate the use of expensive compost, the florist would be saved many dollars each year.

There is an abundance of literature relating to the effect of organic materials on plant growth. The results of these experiments are valuable to the greenhouse man but must be modified because of the great variation of crops grown under glass. Although literature related directly to greenhouse soils and plants is very limited the findings of several investigators have a direct bearing on this problem. Piccioli (9), Northrup (7), Rohland (10), and Jenkins, and Stewart (5) have shown the value of peat and other forms of organic matter in their ability to improve the moisture holding capacity of a soil. Earp-Thomas (3) and Chittenden (2) point out that certain types of peat are excellent carriers of beneficial bacteria. Pember and Adams (8) and Beattie (1) have investigated the merits of various kinds of organic matter in relation to the culture of flowering plants. Mr. Henry Rosacker, Commercial Florist, Minneapolis, Minn., has had remarkable success in the use of a native high-lime peat for greenhouse forcing of tulips, narcissi, and other bulbs and also as a potting soil for the Boston fern.

Materials and Methods

The effect the soil has on the growth of plants depends to a great extent on the species and the temperature at which they are grown. In order to get the reaction of several types of plants the following were selected for these experiments: Freesia (*Freesia refracta alba*) Var. Purity; Cineraria (*Senecio cruentus*) Var. Grandiflora hybrida; Coleus (*Coleus blumei*) a seedling resembling the variety Christmas Gem; and Sweet Pea (*Lathyrus odoratus*) Var. Zvolanek's Rose.

The soil used for the experiment was typical Carrington loam from the college garden which had received light applications of stable manure from time to time but no commercial fertilizer. The organic materials for the experimental plots included, (1) leafmold; (2) well rotted cow manure; (3) chopped oat straw; (4) well decayed peat from Oskaloosa, Iowa (slightly acid in reaction); (5) fibrous peat from the same source as 4 but not so highly decomposed; (6) imported granulated peat moss (a sphagnum peat very acid in reaction); (7) sphagnum moss; (8) shingle-tow, a by-product from shingle mills; (9) ordinary sod-manure compost; (10) garden soil (no added organic matter). The soil and organic materials were mixed by measure at the rate of three bushels of soil to one of the organic material.

The culture of the plants was as near that of commercial practice as possible. This care included regular watering, shifting, spacing of pots and correct temperature control according to the requirements of the plants.

The methods used in soil analysis were as follows: Total nitrogen was determined by the Kjeldahl method; carbonate carbon was determined by the method outlined by Emerson; an electric furnace was used to ascertain loss on ignition; nitrate nitrogen determinations were made by the phenoldisulfonic acid method using a 5:1 extract of air dry soil; the pH of the moist soil was determined by means of the quinhydrone electrode. Total nitrogen, carbonate carbon, and loss on ignition were determined on the materials before mixing. Tests for pH and nitrate nitrogen were made at regular monthly intervals.

TABLE I—Analyses of Materials Used.

Material	Plot Number	Total Nitrogen	Inorganic Carbon	Loss on Ignition	pH Before Combining
		Per cent Dry Wt.	Per cent Dry Wt.	Per cent Dry Wt.	
Leaf mold	1	2.35	0.098	48.2	5.8
Manure	2	3.66	0.621	47.4	7.6
Straw	3	1.74	0.442	89.2	6.9
Well decayed peat	4	5.94	0.130	69.5	6.2
Fibrous peat	5	4.95	0.073	90.1	5.6
Imported granulated peat	6	1.50	0.066	97.1	3.5
Sphagnum moss	7	1.46	0.073	90.0	4.1
Shingle-tow	8	0.02	0.078	98.8	4.0
Compost	9	0.84	0.400	10.5	5.7
Garden soil	10	0.33	0.075	6.9	5.8

Results

The analyses given in Table I show a great difference in the composition of the materials used. Total nitrogen content was highest in well-decayed peat and next highest in the native fibrous peat. These materials contained more nitrogen than manure which would indicate their value as a source of nitrogen for plants.

Table II shows there is very little variation in pH between plots throughout the experiment. All of them had a tendency to increase in alkalinity, probably due to the alkalinity of the water used. Soils treated with granulated peat remained quite acid, while manure treated soil and compost were highest in pH values throughout the experiment. All other materials maintained a fairly constant H-ion concentration.

TABLE II—pH OF SOIL COMPOSITES GROWING SWEET PEAS.

Parts by Measure	Material	Plot	Jan. 5	Feb. 2	Mar. 1	Apr. 26	May 24
1 3	Leaf mold soil	1	6.6	6.6	6.6	6.7	7.3
1 3	Manure soil	2	6.9	6.9	7.1	7.0	7.3
1 3	Straw soil	3	6.6	6.6	6.7	6.8	7.0
1 3	Decayed peat soil	4	6.2	6.3	6.3	6.5	6.8
1 3	Fibrous peat soil	5	6.1	6.3	6.2	6.3	7.0
1 3	Granulated peat soil	6	5.3	5.3	5.3	5.8	6.2
1 3	Sphagnum moss soil	7	6.1	6.1	6.3	6.4	6.6
1 3	Shingle-tow soil	8	6.3	6.4	6.5	6.6	6.8
	Compost	9	6.8	6.7	7.2	7.2	7.2
	Soil	10	6.4	6.6	6.1	6.8	7.0

Sweet Peas. This greenhouse crop was better adapted to this particular project than the others, as it was possible to study the growth response under various soil conditions from a number of different angles. Under ordinary commercial greenhouse conditions the number of flowers produced on each stem of the sweet pea varies from one to five. Stems with three to five flowers have a greater commercial value. In these trials there was little difference in the average number of flowers per stem between the various plots.

Length of flower stem is another factor influencing the commercial value of sweet peas; longer stems being the most desirable. Soils treated with straw, shingle-tow, or fibrous peat produced a larger number of long-stemmed flowers while the plots treated with the more decayed organic materials as leaf mold and rotted manure produced shorter-stemmed blooms. In this respect well-decayed materials ranked on a par with ordinary greenhouse compost. The more fibrous organic materials as shingle-tow, straw, and undecayed peat also produce more long-stemmed blooms during the early part of the flowering season.

The greatest number of flower stems was picked from the garden soil plot given no other treatment. Straw, granulated-peat, and shingle-tow also ranked high. Manure and leaf mold plots produced the smallest total number of flower stems. Fibrous organic materials as granulated peat and shingle-tow outranked other treatments in the production of marketable blooms. This is in accord with the results on the basis of flower stem length previously discussed.

At the close of the experiment the sweet pea vines were cut off to the soil surface and five plants dug from each plot. The roots were carefully washed and examined for nodule formation and growth characteristics. Nodules formed on the roots of plants in all the different plots but there was a wide variation in the size and number which developed under each soil treatment. Very few nodules were formed on plants grown in compost or manure treated soils. The largest nodules were found on plants in the shingle-tow mixture. Straw and peat treated soils produced a large number of somewhat smaller nodules. It is evident that nodule formation was associated with soil mixtures having a low nitrate content throughout the growth period. This is in accord with the findings of Giobel (5) who concluded that nitrate nitrogen in highly concentrated form hinders nodule formation. In this experiment heavy nodule development was directly associated with vigor and flower production of the sweet pea vines.

Vegetative outgrowths known as fasciations were discovered at the base of the plants in some of the plots. The exact cause of this peculiar stem growth is not known but mites or fungi are believed to be responsible. The growth of the sweet pea vines did not seem to be affected. It is interesting to note that these fasciations were most prevalent on soils high in nitrate nitrogen at the beginning of the experiment. This condition existed in the compost and shingle-tow plots and both developed more and larger fasciations than any other soil mixture.

In the light of data secured from the experiments just described it will be of interest to compare these results with those of a similar experiment conducted in 1929 by Lounsberry (7) at Iowa State College. Two varieties of sweet peas were used instead of one to provide an additional check. Lounsberry's results on length of stem and total number of flowers produced are in line with the data discussed in this paper.

Cinerarias. Cinerarias proved to be unsatisfactory material for experimental purposes because of the difficulty encountered in securing a pure strain of seed resulting in somewhat ununiform specimens. Nevertheless they are typical greenhouse pot plants and the behavior of both roots and tops provided an interesting study of the effect of various organic materials in the potting soil. Five extra plots were added to this part of the experiment to determine the effect of feeding the plants in the soils producing the poorer growth. Superphosphate, sodium nitrate, a 4–12–4 complete fertilizer, and hyper humus were the materials added. Seventeen days after shifting into three-inch pots there was no noticeable difference between the fertilized plants and those growing in regular green-

house compost. Plants growing in peat, sphagnum moss, straw, and shingle-tow were distinctly dwarfed and chlorotic. The tendency for roots to develop at the top of the soil ball in the peat treatments and at the bottom in the case of straw mixture was very noticeable.

After 48 days the plants were shifted from the three-inch pots. A growth comparison of all treatments at this time showed the soil mixtures without additional fertilizers ranking in the following order: (1) compost, (2) manure, (3) decayed peat, (4) leaf mold, (5) granulated peat, (6) fibrous peat, (7) sphagnum moss, (8) shingle-tow, (9) straw. Straw supplied with nitrogen, compared favorably with the compost.

Freesias. The freesia corm theoretically contains sufficient plant food in its storage organ or corm to carry the plant thru the flowering stage. Various treatments of potting soil with organic materials and even available fertilizers showed but little variation in growth response. Shingle-tow, sphagnum moss, and straw were inferior to other organic substances in the production of flowers. As a rule soils producing the smallest number of flowers showed an increase in the length of the flower stems.

Coleus. The growth of coleus as determined by height measurements, and foliage color, corresponded very closely with the variation in nitrate nitrogen. The plants treated with straw and granulated peat moss were showing the lack of nitrogen after 100 days. The same effects were noticeable on the shingle-tow plot 30 days later.

Comparing this growth with the nitrate nitrogen we find the plots on which straw and peat were used low in nitrogen at the close of the first month. Shingle-tow plots remained high in nitrate nitrogen for two months and gradually dropped to nothing at the end of five months. After the great drop in nitrogen a gradual rise followed showing a liberation from the organic materials and the plants responded accordingly.

General Discussion and Summary

From the foregoing it will be seen that organic materials added to greenhouse soils have a definite effect upon the resulting plant growth. Pot plants did not respond in the same way as crops growing in bench or ground bed, nor did leguminous crops behave the same as non-legumes. A careful study of the data seemed to indicate that peat, straw, and cornstalks are possible sources of organic matter for greenhouse soils. Their correct use includes a knowledge of the plants used and the addition of fertilizer during the early stages of growth. The organic materials used in this experiment produced no appreciable amount of acidity unless the material added was acid in itself. Organic materials which are more advanced in decay as rotted manure, tend to produce greater alkalinity. Nitrate nitrogen of the soil mixtures in both pots and beds shows a gradual decrease throughout the season. By the use of sodium nitrate a normal growth was maintained in soils which had been lightened by the addition of fresh organic substances such as peat, straw, and shingle-tow. This nitrogen application is necessary until the organic material

reaches a state of decomposition where sufficient nitrate nitrogen is liberated for the plant needs. Soil aeration is an important factor in greenhouse management and the addition of organic material helps this considerably.

The response of legumes differs from non-legumes in the ability of the plant to use atmospheric nitrogen. Inoculated sweet peas produced more long stemmed flowers in soils low in soluble nitrogen than those high in it. Nodule formation, length of stem of sweet peas produced, and nitrate nitrogen in the soil occurred in a direct ratio.

Literature Cited

1. Beattie, J. H. Peat for greenhouse crops. Flor. Rev. 61:43. 1928.
2. Chittenden, F. G. Experiments with bacterized peat, or humogen in 1906. Royal Hort. Soc. Jour. 42:349. 1917.
3. Earp-Thomas, Dr. G. H. Peat as a carrier of bacteria. Chem. Age. 29:491. 1921.
4. Emerson, Paul. Soil characteristics, a field and laboratory guide. McGraw-Hill. 1925.
5. Giobel, C. The relation of the soil nitrogen to nodule development and fixation of nitrogen by certain legumes. N. J. Agri. Exp. Stat. Bul. 436.
6. Jenkins, E. H., and Stewart, J. P. Report on commercial fertilizers. Conn. (New Haven). Agr. Exp. Stat. Report. 39 Pt. 1, p. 69. 1915.
7. Lounsberry, C. C. A comparison of the effect of organic materials on the growth of sweet peas. Unpublished rept. Iowa State College. 1929.
8. Northrup, Z. Soils and soil biology. Mich. Agr. Exp. Sta. Rpt. 32. 236. 1919.
9. Pember, F. R., and Adams, C. E. A study of the influence of physical factors and of various fertilizer chemicals on the growth of carnations. R. I. Agr. Exp. Sta. Bul. 187. 1921.
10. Piccioli, L. Hygroscopicity and hydrologic importance of moss. Abst. Exp. Sta. Rec. 43:812. 1918.
11. Rohland, P. Absorptive power of peat moss. Abst. Exp. Sta. Rec. 34:515. 1915.

The Effects of Hard and Soft Waters on the Growth of Some Plants Under Greenhouse Conditions*

By E. C. VOLZ and E. F. BURK, *Iowa State College, Ames, Iowa.*

IT is commonly known that most water used for greenhouse purposes contains alkaline salts in solution. It has long been a question whether or not these salts are injurious to greenhouse flowers and vegetables when continually given such water. Some growers have persistently used rain water, contending that they obtained more satisfactory growth than when they used hard water.

From the many problems arising in irrigated, flooded and alkaline districts, it is reasonable to believe that the water given to greenhouse soils may also carry injurious salts which might cause damage by their gradual accumulation in the soil of the greenhouse bench. In ordinary greenhouse practice one kind of soil is used for a variety of plants some of which are more tolerant to alkaline reaction while others are better adapted to acid soils. Under such conditions certain elements causing hardness in water may then be beneficial to some crops and detrimental to others. This would imply then that the water applied to greenhouse plants exerts as much influence upon the yield as does the manipulation of the temperature. These facts and possibilities regarding the effect of the water reaction upon plant growth, (both directly and indirectly) are the basis of the studies discussed in this paper.

Wherry (7), Atkins (3, 4), Coville (5), Emmert (6) and others have drawn attention to the importance of the reaction of soils in their relation to plant growth. Arrhenius (1 and 2) emphasized the value of knowing the optimum pH for certain crops as a change in the hydrogen ion concentration of the solute or water may stimulate or retard subsequent growth. Therefore, in planning this problem it was decided to compare plant response and change in reaction as measured by the pH value.

MATERIALS AND METHODS

Waters: The four types of water used in this experiment included rain water, hard "well" water, well water softened by the zeolite chemical process, and well water treated with sufficient H_3PO_4 to change the reaction from alkaline to an acid reaction.

Taking for granted that the hard well water contained injurious mineral salts an attempt was made to improve this condition by running the well water through a zeolite water softener which removed the less soluble calcium and replaced it with the more soluble sodium. The softened water was actually more alkaline than the non-softened, but it was hoped that by periodic leaching the excess salts could be leached out.

Treating the well water with a definite amount H_3PO_4 changed the pH value from 7.5 to 5.4. The purpose of using acid treated water was to determine the effect of neutralizing alkalinity by the acid method used successfully in some field trials, and also by Emmert (6) in greenhouse experiments at Iowa State College.

*See Burk, Master's Thesis, 1927. Iowa State College, Ames, Iowa.

Soils: Assuming that plants make optimum growth at certain pH values, soils were obtained with varying pH values in order to determine the optimum soil as well as to find the effect of water of different types on soils varying in pH Values.

The soils selected for the work were as follows:

1.	New composted soil untreated	pH 6.54
2.	Old greenhouse soil (used one year)	pH 7.11
3.	Old greenhouse soil plus H_3PO_4	pH 5.45
4.	Old greenhouse soil plus H_3PO_4	pH 6.50
5.	Old greenhouse soil plus H_2SO_4	pH 5.50
6.	Old greenhouse soil plus Na_2CO_3	pH 7.85

By numerous systematic trials it was possible to calculate accurately the amount of acid or alkali required to change the soil to the desired pH.

The soils to be used for the plots were weighed, treated and thoroughly stirred before being planted to the respective greenhouse crops.

Plants: The plant materials chosen for this experiment were selected to represent flowering, foliage, fruiting, leguminous and bulbous types of greenhouse crops. The list included: *Lycopersicum esculentum*, tomato (Var. Bonny Best); *Lactuca sativa*, lettuce (Var. Grand Rapids Forcing); *Calendula officinalis*, calendula (Var. Orange King); *Lathyrus odoratus*, sweet pea (Var. Zvolanek's Rose); *Cynoglossum amabile*, Chinese Forget-me-not; *Coleus hybrida*, Coleus (Var. Golden Bedder); and *Freesia refracta alba*, Freesia (Var. Purity).

Calendulas, tomatoes, and lettuce were grown on six soils of different pH values. Each of these soils was divided into four groups, and given hard well water, well water plus H_3PO_4, well water run through a zeolite softener, and rain water respectively. Other plots of six soil groups were fallowed and watered with the four types of water.

Sweet pea, coleus, freesia and cynoglossum were grown in two of the above soils and watered in the same way. This arrangement provided twenty-four individual plots in the experiments with calendulas, tomatoes, and lettuce and eight each for sweet peas, coleus, freesia, and cynoglossum.

Soil pH Determination: In making the pH determinations of the soils, composite samples were taken of several sections from each plot. In the case of tomato, calendula and fallowed soil plots, tests were made at the beginning of the experiment, when the plants were approximately half grown, and the end of the experiment. For the other plants the soil was tested only at the start and finish.

The samples were air dried, at room temperature, then sifted through an eight-inch mesh sieve. From these thoroughly mixed samples 15 gram portions were used for the pH determination by means of the electrometric method using the quinhydrone electrode.† The readings given are for one minute agitation at 25°C.

†For these determinations the writers are indebted to Mr. E. R. Collins of the Department of Chemistry. The work was under the direction of Dr. N. A. Clark of the Department of Chemistry whose cooperation made possible the study of this phase of the problem.

TABLE I—Effect of the Water Reaction and of Calendula and Tomato Upon the Final pH of Soils

Water: Kind	Water: pH	pH of Soil at Start of Experiment	Final pH of Fallowed Soil	pH of Soil After Growing Calendulas	Difference by Calendulas	pH of Soil After Tomatoes	Difference by Tomatoes
Well—H_3PO_4	5.7	$OS+H_3PO_4$ 5.45 pH	6.54	6.12	—.42	6.25	— .29
Rain	7.4	"	7.23	6.90	—.33	6.12	—1.11
Well	7.5	"	7.86	7.03	—.73	6.72	—1.14
Softened	7.6	"	8.34	7.89	—.45	7.13	—1.21
Well—H_3PO_4	5.7	$OS+H_2SO_4$ 5.5 pH	6.48	6.14	—.34	5.99	— .49
Rain	7.4	"	7.14	6.77	—.37	6.29	— .85
Well	7.5	"	7.92	7.17	—.75	6.64	—1.28
Softened	7.6	"	8.07	7.59	—.48	7.04	—1.03
Well—H_3PO_4	5.7	$OS+H_3PO_4$ 6.5 pH	6.69	6.40	—.29	6.61	— .08
Rain	7.4	"	7.49	7.09	—.40	7.04	— .45
Well	7.5	"	7.94	7.70	—.24	7.59	— .35
Softened	7.6	"	8.30	7.95	—.35	7.66	— .64
Well—H_3PO_4	5.7	New Soil 6.54 pH	6.56	6.03	—.53	6.57	+ .01
Rain	7.4	"	7.17	7.05	—.12	7.05	— .12
Well	7.5	"	7.62	7.48	—.14	7.85	+ .23
Softened	7.6	"	8.14	7.75	—.39	7.71	— .43
Well—H_3PO_4	5.7	Old Soil 7.11 pH	6.76	6.48	—.28	6.90	+ .14
Rain	7.4	"	7.82	7.40	—.42	7.38	— .44
Well	7.5	"	8.15	7.58	—.57	8.01	— .14
Softened	7.6	"	8.43	8.19	—.24	8.24	— .19
Well—H_3PO_4	5.7	$OS+Na_2CO_3$ 7.85 pH	6.92	6.74	—.18	7.20	+ .28
Rain	7.4	"	7.83	7.68	—.15	8.03	+ .20
Well	7.5	"	8.27	7.77	—.60	8.28	+ .01
Softened	7.6	"	8.33	7.94	—.39	8.43	+ .10

Water pH Determinations: Samples of the water used were taken about every fourth watering and the pH value determined by the above method. The average of the determinations was used in the final records.

RESULTS

Fallowed Soils: In order to ascertain the effect of the water solutes upon the soils at varying pH values, four-inch pots were filled with each of the six soils and arranged so that duplicate pots were given each of the four waters.

Another set of fallowed soil plots was prepared by first placing one inch of fine gravel in the bottom of each pot before filling with soil to determine if the better drainage afforded by the gravel would aid in leaching the soil of the accumulating salts. These fallowed plots were given the same amount of water as applied to the corresponding plots growing calendulas.

Complete data after five months indicated that:

1. For each water treatment a constant pH is attained independent of the original pH of the soil.
2. The final pH of the soil is a direct function of the pH of the water applied.
3. Although the pH of the water may differ by only 0.1 unit, the accumulation in the soil may amount to several times that amount during a period of only five months.
4. A substratum of gravel under the soil in the pots does not aid to any appreciable extent in leaching out the alkaline salts.

Cropped Soils: The effects of the water reaction upon the final pH of the fallowed soils and of those growing calendulas is shown by the preceding table.

Table I indicates that calendulas‡ lower the pH in all soils in which they grow. On the other hand tomatoes§ cause a lower pH in soils already acid and a higher pH in soils already alkaline.

CROP YIELDS AND CORRELATIONS

The summarized data showing the typical response of each of the seven crops to the various soil and water treatments administered are presented in Tables II, III and IV.

TABLE II—TOTAL RATE OF PRODUCTION* IN RELATION TO SOIL TREATMENTS

Crop	Old Soil Plus H_3PO_4 pH 5.5	Old Soil Plus H_2SO_4 pH 5.5	Old Soil Plus H_3PO_4 pH 6.5	New Soil pH 6.5	Old Soil pH 7.1	Old Soil Plus Na_2CO_3 pH 7.9
Lettuce (lbs.)	7.6	6.2	7.0	9.4	7.0	9.3
Calendula (fl.)	247	255	352	297	280	341
Tomato (lbs.)	90	80	86	90	84	75
Sweet Pea (fl.)				647	768	
Coleus (oz.)				55	53	
Freesia (Fl. Stems)				184	211	
Cynoglossum (Fl. Stems)				113	99	

*Total production for all four waters to any one soil.

‡Similar results were also obtained from sweet peas and coleus.

§Lettuce and synoglossum caused reactions similar to tomatoes.

Table II shows that tomatoes are acid tolerant while lettuce and sweet peas prefer a soil with an alkaline reaction. Sweet peas, coleus, freesia, and cynoglossum were grown only on new soil and untreated old soil.

TABLE III—RATE OF PRODUCTION IN RELATION TO WATER TREATMENTS

Crop	Rank	Rain Water 7.4 pH	Well Water 7.5 pH	Well Water Plus H_3PO_4 5.7 pH	Softened Water 7.6 pH
		1	2	3	4
Calendula	Yield in flowers	491	426	559	399
	Rank	1	3	2	4
Tomato	Yield in lbs. & oz.	131 & 15	119 & 13	127 & 1	126 & 4
	Rank	1	4	2	3
Lettuce	Yield in lbs. & oz.	11 & 12	11 & 11	11 & 3	11 & 7
	Rank	1	2	4	3
Coleus	Yield in oz.	32.5	26.1	25.8	22.8
	Rank	1	2	3	4
Sweet Pea	Yield in flowers	506	316	115	478
	Rank	1	3	4	2
Cynoglossum	Yield in flowers	68	47	57	40
	Rank	1	3	2	4
Freesia	Yield in flowers	110	105	95	85
	Rank	1	2	3	4

Table III clearly shows the superiority of rain water and the detrimental effects of the chemically softened water. The value of rain water is also illustrated in Table IV.

TABLE IV—YIELD INCREASE OF RAIN WATER OVER WELL WATER

Crop	Calendula	Tomato	Lettuce	Coleus	Sweet Pea	Cynoglossum	Freesia
Per cent Increase....	15.3	10.9	None	16.5	60	44.7	4.7

Average increase for all crops under experiment 20%

DISCUSSION AND SUMMARY

An examination of the data presented in these three tables emphasizes the fact that greenhouse plants vary in response to soil and water conditions. Tomatoes and calendulas are acid tolerant while sweet peas strongly favor alkaline water and soil reactions. This experiment would also include lettuce in the alkaline tolerant class when comparing only old soils.

Although new greenhouse soil gave better results with most of the plants used in these trials, nevertheless, the yield on old soil was exceedingly good and substantiates the theory that yearly changing of greenhouse soils is unnecessary for some crops.

H_3PO_4 is undoubtedly superior to H_2SO_4 in treating soils to change the pH value. Soils in which plants are growing evidently do not maintain a constant pH value. This can be greatly stabilized by treating the water with H_3PO_4.

Rain water is unquestionably superior to the other types of water used in this experiment. Water softened by the zeolite process ranked fourth in efficiency, and the evidence shows that changing the calcium radicle for a sodium radicle is not the proper method of softening water for plant use. This, of course, does not indicate that other methods of softening water may not be employed.

Conditions in greenhouses where alkaline waters are used are such that the soils therein tend to become alkaline.

Plants do not have a constant pH optimum, but a pH optimum for each set of conditions.

Alkaline reactions cause greater root diameter while acid reactions cause a more fibrous root development.

Further experiments are recommended to determine the soil pH requirements of important greenhouse crops.

Literature Cited

1. Arrhenius, O. Absorption of nutrients and plant growth in relation to hydrogen ion concentration. Jour. Gen. Physiol. 5:81. 1922.
2. Arrhenius, O. Soil acidity and plant growth. Abst. in Chem. Abst. 19: 2254. 1925.
3. Atkins, W. R. G. Discussion of coloring hydrangeas with iron sulfate and aluminum sulfate. Sci. Proc. Royal Dublin Soc. 17:201. 1923.
4. Atkins, W. R. G. Some factors affecting the hydrogen ion concentration of the soil and its relationship to plant distribution. Sci. Proc. Royal Dublin Soc. N. S. 16:3690. 1922.
5. Coville, F. V. Agricultural use of acid soils. Jr: Am. Peat Soc. 18:5 and 17. 1925.
6. Emmert, E. M. A study of the changes in greenhouse soils and their effects on the yields of tomatoes and lettuce. Unpublished thesis (M. S.) Library, Iowa State College, Ames, Iowa. 1924.
7. Wherry, E. T. Soil reaction in relation to Horticulture. Am. Hort. Soc. Bul. 4. May 1926.

The Leaching of Nitrates and Phosphates from Some Greenhouse Soils

By DAVID C. FAIRBURN, *Iowa State College, Ames, Ia.*

FOR years the commercial growers of greenhouse crops have been confronted with the routine problem of changing the soil in the benches. The amount of labor and expense involved is tremendous. Must we of necessity continue to accept this task or can it in some way be partially eliminated?

It has been suggested that the loss of plant food elements in the drainage water, resulting in a so-called "soil starvation," may be responsible for the unproductiveness of a given soil. It is a well-known fact that a certain percentage of the water applied to the soil in the greenhouse is lost by percolation through the bottom of the bench. Is it not reasonable to believe that this drainage water might carry with it appreciable amounts of soluble plant food elements? If this were true, the loss of nutrient salts could be paramount in the explanation of the foregoing problem.

Previous lysimeter investigations of Lyon and Bizzell (5, 6), Collison and Walker (1), Fraps (3), Hall (4), and others have definitely indicated the presence of nutrient salts in the drainage water from various types of soil. The present studies were conducted to determine if the leaching of nitrates and phosphates is of sufficient consequence to cause the soil in the greenhouse benches to become unproductive.

Thirty-six linear feet of raised wooden greenhouse bench was divided into nine sections, each 3 ft. long and 4 ft. wide, leaving 16-inch intervals between plots. Each plot was equipped with a galvanized sheet iron lysimeter pan to catch all of the drainage water which was collected in a receiving flask at the base of the pan.

Three types of soil were used, namely, unfertilized field soil for check plots, greenhouse compost, and a mixture of field soil and decomposed Iowa peat in a ratio of 3 to 1 respectively. *Calendula officinalis* was the plant used in this work. Rain water from the college cistern was used to avoid the accumulation of salts. The inner surfaces of the plots were heavily coated with paraffin, and the floor boards spaced to permit ample drainage into the lysimeter pans beneath. One inch of fresh oat straw was placed in the bottom of each plot to prevent the soil from falling through the spaces between the boards. The soil was thoroughly mixed and placed in the plots to a depth of 6 inches. All the plots were run in triplicate.

Twelve calendula seedlings of uniform size and vigor were placed in each plot Jan. 23. The plots were watered whenever the soil showed signs of drying out. Sufficient water was applied to each plot to furnish an adequate sample of percolate for the chemical analysis. Toluene was added to the percolates to prevent denitrification.

A summary of the volume of water applied, and the amount of solution leached from the plots is given in Table I. An attempt was made to maintain a uniform watering schedule for all the plots,

but this plan was abandoned because the increased plant growth on the compost plots and the variation in the water-holding capacity of the three types of soil called for differences in water treatments in order to maintain satisfactory plant growth.

TABLE I—SUMMARY OF THE VOLUME OF WATER APPLIED AND THE VOLUME LEACHED FROM THE NINE EXPERIMENTAL PLOTS, EXPRESSED AS LITERS.

Runs		Field Soil Plots		Compost Plots		Field Soil Plus Peat Plots	
No.	Date	Applied	Leached	Applied	Leached	Applied	Leached
1	1/27/29	90.84	8.53	90.84	13.17	90.84	2.63
2	2/17/29	113.55	15.31	113.55	15.50	113.55	4.75
3	3/6/29	90.84	7.92	90.84	7.92	90.84	4.94
4	3/18/29	90.84	6.55	90.84	10.55	*	*
5	3/26/29			90.84	8.50		
6	4/2/29	90.84	5.27	90.84	9.71	158.97	5.50
7	4/6/29			90.84	8.55		
8	4/12/29	90.84	7.18	68.13	5.10		
9	4/15/29			90.84	8.44		
10	4/18/29	90.84	5.25	90.84	6.72	113.55	3.34
11	4/26/29			90.84	11.87		
12	4/30/29			90.84	6.24		
13	5/5/29	90.84	5.87	90.84	5.95	136.26	6.91
Total		749.43	61.88	1180.92	118.22	704.01	28.07
Per cent percolate		8.2		10.1		3.8	

*Blanks indicate that water was neither applied nor leached.

The moisture requirement of the plots varied greatly, depending on the type of soil, and the extent of plant growth. It is evident that a loose, fibrous soil such as greenhouse compost permits greater percolation than does a heavy field soil. The addition of peat increased the water-holding capacity of field soil 38.2 per cent. This suggests the value of combining peat with compost to prevent excessive percolation.

A very striking feature was the pronounced variation in the opacity of the percolates at different periods during the experiment. In all probability this variation was due to the presence of soluble organic compounds evolved from the chemical and biological activities within the soil. It would appear that the active causes of this change in opacity of the percolates are cyclic in nature.

The nitrate nitrogen in the leachings was determined by the standard phenoldisulfonic or colorimetric method, using 100 ml. aliquots in duplicate with 20 ml. of a standard potassium nitrate solution as a basis of comparison and calculation. Table II gives the results of these determinations. To present the data in a convenient and suggestive form, the nitrates are expressed in pounds of sodium nitrate per acre of 2,000,000 pounds.

The consequent loss of nitrate nitrogen through the process of leaching is significant. The greatest loss of soluble nitrogen occurred at the beginning of the growing season. As plant growth increased, there was a rapid decrease in the amount of nitrates leached till somewhat of a constant value was reached from which there was only slight fluctuations. In all cases there was a direct relationship between the total nitrogen of the soil, and the nitrate nitrogen present

TABLE II—LOSS OF NITRATE NITROGEN EXPRESSED AS POUNDS OF $NaNO_3$ PER ACRE.

Runs		Plot Number									
No.	Date	(1) Field Soil	(2) Compost	(3) Field Soil Plus Peat	(4) Compost	(5) Field Soil	(6) Field Soil Plus Peat	(7) Compost	(8) Field Soil Plus Peat	(9) Field Soil	Total Loss at Different Periods
1	1/27/29	0.93	21.42	1.05	41.23	3.69	0.91	45.82	1.68	3.83	120.56
2	2/17/29	7.89	65.01	0.47	57.89	8.08	2.83	60.23	1.46	10.53	217.39
3	3/6/29	0.59	14.18	0.58	23.99	2.42	0.58	25.42	4.02	3.85	75.63
4	3/18/29	0.09	10.60		13.99	0.07		10.38		0.12	35.25
5	3/26/29	*	3.16		6.31			2.60			12.07
6	4/2/29	0.03	1.71	0.18	1.91	0.03	0.01	2.09	0.05	0.01	6.02
7	4/6/29		3.29		3.46			2.64			9.39
8	4/12/29	0.67	3.73		1.73	0.35		2.20		0.48	9.16
9	4/15/29		3.16		2.93			1.77			7.88
10	4/18/29	0.07	3.29	0.16	4.61	0.39	0.52	0.41	1.87	0.61	11.92
11	4/26/29		1.75		0.64			0.90			3.29
12	4/30/29		1.42		1.59			1.15			4.16
13	5/5/29	0.20	1.54	0.54	1.39	0.35	0.24	0.73	0.30	0.23	5.52
Total loss for each plot		10.47	134.26	2.98	161.67	15.38	5.09	156.34	9.38	19.66	

*Blanks indicate that no percolates were available for analysis, because no water was applied at those periods.

in the drainage water. Peat was found to be an aid in preventing the loss of nitrates by controlling excess percolation.

Total nitrogen of the soils was determined by the Modified Kjeldahl method, using 10 gram soil samples in duplicate for each analysis. The results are given in Table III. Since field soil lost by far the greatest amount of total nitrogen, it would seem that organic matter functions in nitrogen economy. Peat evidently conserves the nitrogen by retaining the soil moisture.

TABLE III—TOTAL NITROGEN OF THE SOIL EXPRESSED AS POUNDS PER ACRE OF 2,000,000 POUNDS.

Soil	Beginning of Experiment	End of Experiment	Loss
Field soil	6280	5880	400
Compost	8780	8630	150
Field soil+peat	6950	6840	110

Total phosphorus of the soil at the beginning and at the end of the experiment was determined volumetrically using 2-gram soil samples in duplicate. The results indicated a decided increase in phosphorus. If this was more than accidental, the writer is unable to assign any significance to the fact.

Soluble phosphorus was determined by precipitating the phosphorus as ammonium-phospho-molybdate, making the solution alkaline with sodium hydroxide, and titrating the excess of alkali with standard hydrochloric acid.

The results of these analyses showed that soluble phosphorus was leached out of the soil in amounts so infinitesimal that the loss is to be regarded as insignificant. It may be said that only a trace of phosphorus was detected in the percolates.

From the pH tests it was observed that organic matter does not increase the acidity of the soil, unless the material added is acid in itself. It was further noted that the general trend of the pH value was towards the neutral point.

The marked variation in the plant growth on the three types of soil is worthy of attention. The compost soil was outstanding in the production of vegetative growth. The peat composite and field soil were deficient in available nitrogen, and the plant growth was correspondingly inferior. Table IV gives a summary of the flower production of the three soils. Flower production was directly proportional to the vegetative development of the plants. The quality of the flowers was inverse to the number produced.

TABLE IV—SUMMARY OF FLOWER PRODUCTION

Soil	Total Number of Flowers	Average Length of Stems in cm.	Average Diameter of Flowers in cm.	Average Quality of Flowers
Field soil	156	14.8	8.3	average
Compost	1112	16.8	7.2	inferior
Field soil+peat	212	13.3	7.9	average

Conclusions

1. Appreciable amounts of nitrate nitrogen are leached out of greenhouse compost soil by percolation.

2. Moderate applications of water are suggested at the beginning of the growing season in contrast to the prevailing practice of saturating the bench soils, especially after applying manure mulches.

3. The amount of phosphorus lost through percolation is insignificant.

4. This investigation shows that the leaching of available nitrogen is important, and opens up a field of work which may lead to a revision of the present day soil treatments in the greenhouse.

The writer wishes to extend recognition to Professor E. C. Volz, and Dr. Paul Emerson for their valuable assistance in this work.

Literature Cited

1. Collison, S. E., and Walker, S. S. Loss of fertilizers by leaching. Fla. Agri. Exp. Sta. Bul. 132:1. 1918.
2. Emerson, Paul. Soil characteristics. McGraw-Hill Book Co. 1928.
3. Fraps, G. S. Losses of moisture and plant food by percolation. Tex. Agr. Expt. Sta. Bul. 171:1. 1914.
4. Hall, A. D. The book of Rothamsted experiments. 1905.
5. Lyon, T. L., and Bizzell, J. A. Lysimeter experiments. N. Y. Agr. Exp. Sta. Cornell Memoir 12:1. 1918.
6. Lyon, T. L., and Bizzell, J. A. Lysimeter experiments No. II. N. Y. Agr. Exp. Sta. Cornell Memoir 41:1. 1921.

The Role of Pistil Length in the Development of Forcing Tomatoes

By EARL F. BURK, *University of Wisconsin, Madison, Wisc.*

ONE of the major problems in the production of winter forcing tomatoes in the United States is to secure a large fruited variety which will set fruit during the short days of the winter.

The large-fruited American varieties, such as the Bonny Best, fail to set satisfactory crops of fruit during these short days. The English varieties, such as the Princess of Wales, set fruit abundantly during the short-day period, but the samll size and less desirable quality of the fruit are objectionable to the American trade.

A study of each of these varieties revealed that the length of the pistil in the Bonny Best varied according to the length of photo-period and according to the intensity of the light. When grown in short photo-period (8 hours) the pistils were much longer than the stamens and when grown in long photo-period (16 hours) the pistils did not extend beyond the stamens. The pistils of the Princess of Wales for the most part remained shorter than the stamens in both long and short photo-period. During the short winter days the pistils of the Bonny Best were $\frac{1}{16}$ to $\frac{3}{16}$ inch longer than the stamens of the same flower. In contrast to this the pistils of the Princess of Wales were $\frac{1}{16}$ to $\frac{1}{32}$ inch shorter than the stamens of the same flower.

After testing out the potency of the pollen and pistils of the Bonny Best and finding them functional, the hypothesis assumed was that the length of the pistil, as influenced by the short day, makes it mechanically very difficult for the Bonny Best to self pollinate sufficiently to produce a good set of fruit.

It was then decided to try to breed a new variety possessing the desirable size and quality for the American trade and having the short pistil which would enable easier self pollination during the short winter days. The parent stock consisted of the Bonny Best, chosen for its desirable size and quality and the Princess of Wales for the short pistil and prolificacy.

The F_1 generation was planted in the garden in 1928, and selections were made on the basis of plant condition and fruit size and quality.

The following winter, plants produced by many of the seeds from the choicest of the F_1 population were planted in the greenhouse. From the 1000 F_2 plants grown to flowering, there were about 100 plants with either short or medium short pistils that were selected and brought to fruiting. Only one-third of these showed promising characteristics at fruiting time. This small portion was used as the foundation stock for the F_3 generation.

In the summer of 1929 over 7,000 hybrid plants were grown in the field. There were 2,000 plants from the F_3 seed produced in the greenhouse and 5,000 plants, the remainder of the F_2 generation, not yet tried. Selection from these two generations was based on the desirable qualities of short pistil, vigorous productive plant, and fruits of good size and depth, and free from the tendency to sun scald and crack.

The records of pistil lengths of the F_2 generation indicate that there was a 1:4:6:4:1 distribution of long, medium long, medium, medium short, and short pistils. Selection for short pistils demonstrated transgressive inheritance of pistil length in that individuals were produced with pistils shorter than the short pistilled parent.

In the third generation some families had 100 per cent short pistils. This indicates a homozygous condition for this character. In these strains a number of good plants were found with desirable fruits from which the F_4 generation is being grown this winter for further test and selection in the greenhouse.

The present results indicate that satisfactory forcing varieties can be produced by breeding and selection of plants, which have desirable fruit types together with short pistils, to insure self pollination.

The Influence of Photoperiod Upon Seed Potato Stock

By R. H. ROBERTS, *University of Wisconsin, Madison, Wisc.*

The material contained in this paper will be published in the report of the Potato Association of America.

Greenhouse Cucumber Pruning Tests*

By H. D. Brown, *Ohio State University, Columbus, Ohio*

THE data secured from cucumber pruning tests carried on in the Purdue University greenhouses for three years clearly indicate that timely pruning is highly essential. In other words the parts should be removed while still quite small so that the least amount of food synthesizing areas will be disturbed and so that growth will be quickly diverted to permanent plant parts. The yields of cucumbers as shown in Table I are lower for all three years (lot 4) where a considerable amount of foliage was removed as compared to lot 3 where the foliage was removed when it first formed. Moreover, the yields of the heavily pruned lot 4 are in general smaller than those from lots 1 and 2 where less foliage was actually left on the plants. In lots 3 and 4 the leaf on one node past the first female blossom was left to develop.

In lots 1 and 2 the side branch growth was terminated a few inches beyond the first female blossom. In lot 1 the leaf near the blossom was allowed to grow but in lot 2 this leaf was removed. All parts pruned from lots 1, 2, and 3 were removed while they were very small. They were in fact so small that they were still very brittle and were easily broken from the plants by a slight pull when grasped between the thumb and index finger. During the three Springs that these tests were carried on, the plants of all lots were very free from diseases including mosaic. It is thought that the removal of brittle plant parts as indicated would reduce the spread of mosaic and bacterial wilt because of the non transfer of plant sap as compared to any method involving the use of knives. Data regarding this question are, however, not available due to the complete freedom from disease of the plants in all lots.

The yields of lot 2 are actually greater, though not significantly greater, than the yields of lot 1 in spite of the fact that the leaf adjacent to the developing fruit was removed. This would seem to indicate that food translocation in the cucumber was very rapid and effective. An effort was made to determine whether or not the green fruits were manufacturing their own plant food. Fruits grown in sacks were almost of normal size although they contained but little green pigment.

Lot 3 yielded slightly better than lots 1 and 2 which developed less foliage especially near the fruits. Although the data are somewhat conflicting it is perhaps a safe plan to allow the leaves adjacent to the cucumber fruits as well as the leaves on the first nodes beyond the fruits to develop if the most satisfactory yields are to be secured.

The Davis Perfect variety was grown in 1925 and the Abundance variety was grown in 1926 and 1927. From Table I it is obvious that the Davis Perfect outyielded the Abundance although the individual Abundance fruits were considerably larger. The plants were all set 18 inches by 50 inches in rows running north and south

*Published with the approval of the Director of the Purdue Agricultural Experiment Station.

TABLE I—AVERAGE YIELD OF CUCUMBERS PER PLANT, PURDUE UNIVERSITY GREENHOUSES.

Treatment	Year	No. 1		No. 2		Culls		Total		Ave. Wt. per Fruit in Lbs.
		No.	Lbs.	No.	Lbs.	No.	Lbs.	No.	Lbs.	
Lot 1. Side branch growth terminated a few inches beyond node on which first female blossom appeared	1925							24.90	18.59	.75
	1926	7.8	8.10	4.2	3.26	.17	.11	12.17	11.47	.94
	1927	5.1	5.87	3.5	3.35	2.29	1.47	10.89	10.69	.98
Average		6.45	6.99	3.85	3.31	2.23	.79	15.99	13.58	
Lot 2. Side branch growth terminated a few inches beyond node on which first female blossom appeared. Leaf adjacent to blossom removed.	1925							24.00	18.83	.78
	1926	8.1	8.21	4.6	3.60	.23	.10	12.93	11.91	.92
	1927	5.8	6.65	3.7	3.44	1.3	1.00	10.80	11.09	1.03
Average		6.95	7.43	4.15	3.52	.77	.55	15.91	13.94	
Lot 3. Side branch growth terminated a few inches beyond the second node formed beyond the first female blossom.	1925							24.80	20.31	.82
	1926	8.8	9.31	5.1	4.02	.17	.10	14.07	13.43	.95
	1927	6.6	7.29	3.7	3.10	1.9	1.26	12.20	11.65	.95
Average		7.70	8.30	4.4	3.56	1.04	.68	17.02	15.13	
Lot 4. Side branch growth terminated a few inches beyond the second node formed beyond first female blossom. Pruning delayed until 6 or 7 nodes had formed past the first female blossom	1925							21.10	17.45	.83
	1926	8.4	8.76	4.3	3.35	3.35	.13	12.83	12.16	.95
	1927	4.6	4.96	3.4	2.91	1.2	.74	9.20	8.61	.94
Average		6.5	6.86	3.85	3.13	.67	.40	14.38	12.74	

on the south half of the ground beds in the University greenhouses. Adequate guard rows were provided in all instances. In 1925 the tests were run as single plots, in 1926 the plots were triplicated and in 1927 the tests were run in duplicate. All the soil was steam-sterilized each year. All blossoms were hand-pollinated during the course of the tests. The tests were discontinued each year when the fruits to a height of approximately six feet had been harvested. After this time the growth of secondary shoots started at many points and a second crop of fruit was harvested if the price was satisfactory. The yield records in 1925 extended from May 30 to July 20; in 1926 from March 16 to June 18; and in 1927 from March 29 to May 18. In all cases the seed was germinated in flats, the seedlings transplanted to 4 inch pots, and the selected plants set in the ground beds as soon as they were large enough. The vines were trained to single stems and supported by jute twine stretched between wires at the base and top of the plants.

In 1927 yield records of fruit harvested from the main stems and laterals were kept separate. These data are shown in Table II. It is apparent that the crop maturing on the main stems of the Abundance cucumber is very satisfactory from the standpoint of yield and, especially, size of fruit.

TABLE II—AVERAGE YIELD FROM MAIN STEMS AND LATERAL BRANCHES, ALL LOTS, PURDUE UNIVERSITY GREENHOUSES, 1927.

Location	Number	Pounds	Ave. Wt. in Pounds
Main Stems............	4.92	4.93	1.00
Lateral Branches.......	6.04	5.69	.94

Concrete Benches for Greenhouses*

By W. B. BALCH, *Kansas Agricultural Experiment Station, Manhattan, Kansas.*

ONE of the big expenses in the management of a greenhouse is the replacement, every few years, of the wooden benches. This expense is not only for the lumber used, and the labor involved in pulling down the old benches and building the new but also in moving the soil out of the houses and then later carrying it back. Often this requires so much time that a summer crop that might be raised in the bench is lost.

The expense of soil removal has not been taken very seriously because it has been thought that after a few years the soil in a greenhouse became "sick" and thus was valueless until it had been out in the weather for a year or two. The experiments at the Rothamsted Station in England indicated that the condition known as greenhouse sick soil could be overcome by sterilization with steam.

In order to sterilize the soil it was necessary that a tighter bench than the wooden bench or bed be used, because the steam leaks from the wooden bench so much that the cost of the sterilization is increased and its efficiency decreased. Therefore to save the expense of replacing the wooden benches and beds and to provide a holder for the soil that would be satisfactory for sterilization, concrete was considered by the Kansas Agricultural Experiment Station.

There seemed to be no literature available that would give one assistance in the construction of such beds. As a result, engineers were called in and plans and specifications were drawn up. The first concrete bench was a raised one constructed in 1921. It might be well to add here that it serves as an example of what not to do. The walls are 6 inches thick and the wasted space is unbearable to a greenhouse man. The cost of this bench was so great that the idea of concrete was temporarily abandoned. We no longer have the cost figures but no one could afford the method of construction used even if he had to remove the soil every year and put up new wooden benches.

During the winter of 1921–22, much time was spent on the problem and with the assistance of the greenhouse foreman, a plan was devised to be tried the next summer.

The problem was twofold. Both ground and raised benches were wanted. Cheaply built benches were needed that would be lasting, drain excess water, and not take up too much room, if concrete was to be used successfully.

With the ground benches this was rather easy. A wall of concrete reinforced with hog wire around the pit was used in the bed. Old 2-inch planks were used for forms. The mixture used for this job was four parts of sand to one of cement. Rock or other material was not used. The bed was 95 feet long and 6 feet wide. The walls were 2

*Contribution No. 89 Department of Horticulture Kansas Agricultural Experiment Station.

inches thick at the top and 3 at the bottom. This first wall was 2 feet high, 18 inches of it being above the ground.

A wall of this description contains 64 cubic feet. This was the amount of sand that would be needed for the job. The cement in such a mix does not add to the bulk. The sand cost $8.00 delivered, and cement cost $8.25. The lumber for the forms was picked up at various prices, some of it being salvaged from the abandoned bed. It is rather hard to get the cost of this material especially as it can be used year after year for the same purpose and then used for a frame or a hotbed when all the concrete work is in. The actual labor for this first job, exclusive of the removal of the old lumber and the old soil, was 88 hours. The average price for the labor was 30 cents per hour making the total labor cost $56.40. The hog wire reinforcing cost $2.17 and the cross ties put in the end and every 20 feet through the bed cost 54 cents, making the total cost of materials $75.36.

The next year another ground bed was constructed. This time 6 inches of the wall was built above ground instead of 18. This of course means that fewer forms are needed but excavating is necessary making the cost of the two types about the same. The writer sees no difference in the two types of beds. Various florists in the state have seen them and some adopt one, some another. It seems that fancy is the deciding factor.

All the ground beds are equipped with two lines of farm tile which run the entire length of the bed. This tile serves a dual purpose. During the growing season, it is used for irrigation. Being on the bottom of the greenhouse soil a large amount of water is necessary at each irrigation but frequent watering is not necessary. It saves labor, too, in that the hose is merely run to the tile and need only be observed occasionally to be sure that too much is not applied. This was the only method of watering used for a couple of years but we found that it apparently brought an excess of salts to the top which made a layer of slightly alkaline soil and the plants suffered from it. Water is now applied that way about half the time, the rest of the time it is applied in the ordinary manner. The main purpose of the tile, of course, is for sterilization of the beds with steam.

Crops are growing in the beds continually for at least nine months of the year. After the last crop has been taken out the soil is sterilized. The steam comes in under no pressure and is applied until the soil at the top of the bed is 200 degrees F. At times the soil in parts of the bed has been as high as 210 degrees. The writer has never found it any higher.

According to most of the workers on soil sterilization with steam, 175 degrees seems to be sufficient. When the maximum temperature has been attained the steam is turned off. It takes about 10 hours for the soil to cool off enough to allow one to hold his hand on it. It takes about two days for it to dry enough to be worked. On this account the soil has not been covered to keep the heat in though it might be cheaper to do this. A member of the engineering department here has figured out the cost of a sterilization. Using coal worth $8.00 a ton it costs $48.00 to sterilize a bed 95 feet long, 6 feet wide, and 2 feet deep. Thus instead of carrying out the soil

each year, it can be kept in the benches. It is free from injurious organisms, it is of good fertility and one has an idea of what it may need in order to produce a better crop. The soil has not yet been changed since 1922 and so far there seems to be no evidence of greenhouse sickness. It produced a better crop of chrysanthemums this fall than ever before. There were more plants per square foot than usual and they were grown to three flowers instead of two. The blooms were sold at $6.00 per dozen.

Much of this has little to do with the actual construction of concrete beds but is mentioned to indicate why concrete beds are better than wooden ones even though they cost more. This concrete bed cost $149.39 and is still there after seven years. Presumably, it will be good for 43 more for it is claimed that 50 years is the life of a concrete job. The material for a wooden bed of this size would have cost $64.40 if No. 2 rough cypress had been used and $40.00 if pecky cypress had been used. The soil in it could not have been sterilized so it would need to be replaced in about five years and some money would be needed for repairs. From the point of view of economy, the concrete is the better.

Some of the greenhouse men said that crops would not grow so well in concrete as in wooden beds. To test this two parallel beds in a house were planted to carnations. One was concrete, the other wood. Beds are not usually used for carnation culture but it was decided to try them in the beds and to have a bench of the same variety in the same house. The plants in the raised bench averaged 11 blooms per plant, in the wooden bed 12.24 blooms per plant and those in the concrete bed 14.01 per plant. There were 456 plants in each test and it was conducted for two years. Since then the carnations have all been grown in ground beds and the crop has averaged about the same as it did the first two years. This year the bed that was first planted to carnations is now growing its fifth crop of carnations and the soil has received no treatment other than sterilization, manuring and the feeding of a complete fertilizer every three weeks from the time the plants have been in the beds 60 days until Mother's Day. The crop now looks as good as ever though we have had such dark weather during December that the buds have not opened and it may be deceiving.

In building concrete benches instead of ground beds the problem is difficult. The walls 2 to 3 inches thick had proved satisfactory for the beds. Would they for the benches? We knew no other way than to try it. The houses are all 25 feet wide, ridge and furrow type. The two sides have benches, in the center of the house is a walk and on each side of that is a bed. It was decided to build the benches in one cast or mold. That is the benches in two adjoining houses would be one wide bench separated by the glass wall that ran part way down to the floor. Legs were made of old inch and a quarter gas pipe which were set in a block of concrete. A leg was put every 6 feet. Running from the opposite leg is a piece of $\frac{3}{4}$-inch angle iron. This carries the load of the bench and the soil. The bottom is $2\frac{1}{2}$ inches thick, the side walls tapering from 3 inches at the bottom to 2

at the top. The side walls are 10 inches high on the out side giving room for 7½ inches of soil. Usually only 5 inches of soil are put in the benches and a mulch of an inch or two kept on for most crops. The beds are three feet wide on each side of the partition giving them a span of 6 feet.

A bed of this depth was too shallow for 4 inch farm tile for the sterilization. Instead of the tile, old 1¼ x 1½ inch gas pipe are being used. The pipe was drilled at intervals of three feet, the holes being on alternate sides. It was laid on the bottom of the bench so the holes were at right angles to the sides. Sterilization has been effective with this but it has not proved satisfactory for irrigation. Drainage was obtained by having a one-inch hole for every 1½ feet of bench. No difficulty has been experienced from poor drainage.

The cost of this bench is, sand $37.31; cement $39.42; cross ties 63 cents; labor $86.10; and wire $8.99, a total of $172.45.

If built with lumber the cost would have been about $100.00. No. 2 cypress and $70.00 for pecky cypress compared with $86.35 for the concrete benches which includes also a partition wall three feet high.

The crops produced on the concrete benches during the first 3 years showed an average increase of 13 per cent over that of the wooden benches. In no case was there a reduction in the crop grown in the concrete bench. Of course, part of this increase may be due to the fact that there was about 6 inches of soil in concrete benches and only about 4 in the wooden benches. However, 6 inch side walls in the wooden benches would increase the cost of that bench.

It is the writer's opinion that the use of concrete for the construction of beds and benches for greenhouses is to be recommended from an economic point of view. In addition it is cleaner, neater and reduces the fire, insect, and disease hazard and saves labor in watering, removing the soil and continual rebuilding. It has been figured out that if the florists of Kansas would adopt concrete for this purpose a saving of $133,000.00 would be made every 5 years besides a reduction in use of insecticides, fungicides, and a saving of crops lost by insects and disease.

The florists of the state are taking an interest in the concrete and are adopting it slowly in their houses.

Transmission Studies with the New Psyllid-Yellows Disease of Solanaceous Plants

(A Preliminary Report)

By A. M. Binkley, *Colorado Agricultural Experiment Station, Fort Collins, Colo.*

Economic Importance and Distribution

In Colorado: The early crop of potatoes on the Western Slope district suffered losses in 1926 and 1927 amounting in many instances to complete failure. Many growers did not produce enough tubers to equal the amount of seed planted. The losses were caused by an unusually destructive disease and were first observed in 1926. At that time there was considerable difference of opinion in regard to the cause, however later it was found to be associated with the common tomato psyllid (*Paratrioza Cockerelli* Sulc.) The losses were so severe in 1926 as to reduce the shipments of potatoes from 600 to 150 carloads. In 1927 the trouble was again present, however to a more destructive degree, since shipments were reduced from 600 to a 2 carload crop. In 1928 the injury was not so great; a loss of approximately 10 per cent was reported. In 1927 the disease was present in the Fruita district of Mesa County, in the Gunnison Valley of Delta County, in the Uncomphagre district in Montrose County, and in the Rifle district of Garfield County. These counties are located on the Western Slope of Colorado where the main crop, which consists of the Irish Cobbler variety, is usually planted during late March to the middle of April and is harvested during July. Late varieties such as the Peoples Russet, Charles Downing, and Rural New Yorker did not appear to be as severely damaged as the Irish Cobbler variety.

The disease has been reported as present in other sections of the state, but only a small amount of damage was observed on tomatoes and other solanaceous crops in Northern Colorado during the 1928 season. Commercial tomatoes grown in the college greenhouse during the winter 1829–1929, even where the best known methods of control were used, sustained losses as high as 31 per cent.

Utah: In 1927 the disease was reported as present in 23 counties throughout Utah. (1). The survey has shown the disease to be most destructive in Davis, Weber, and Washington Counties. The financial losses in Davis and Weber Counties amounted to approximately 60 per cent of the crop, many fields of early potatoes were not even harvested, while yields of late potatoes seldom exceeded 70 per cent of the normal production. In Washington County, in southern Utah, the potato crop was reported as a total failure and potatoes were not even harvested in the home gardens. Such a complete failure has not been previously reported in that county. The infestation of the fields varied from almost none to 100 per cent. Linford (1) states that the average reduction in yield for the entire state was 25 per cent of the total yield, as a conservative estimate. He further states, "even this figure fails to reveal the potential

menace of psyllid yellows to profitable potato culture, even to the agricultural prosperity of the inter-mountain region. In areas where potatoes are now a chief crop, frequent repetition of the 1927 outbreak would be disastrous."

Other States: The disease has been reported as appearing in the potato fields of Idaho, Montana, and Wyoming. (2). The disease is severe, and of such a destructive nature that a plant once affected, especially in the early stages of growth, is practically a total loss. The rate of spread is rapid, and as yet the disease has not yielded to control measures. There is a possibility that it may become one of the most destructive diseases of solanaceous crops in the inter-mountain region. It is therefore considered important to re-direct attention to it and report upon preliminary studies and observations. The insect has been reported by Essig (3) as being present in California, Colorado, Utah, Arizona, and New Mexico.

Host Plants of the Insect

The host plants listed by Essig (3) are: alfalfa, arborvitae, solanum species, spruce, tobacco, datura, nightshade, tomatoes, pine, and potato.

Early Control Work

Early control work in Colorado shows that the insect has been present in Colorado for a number of years. The ninth annual report (1917) of the State Entomologist gives results secured with control measures. In the report the common psyllid was then recognized as of economic importance in tomato fields and in gardens of this state. However, the injury caused by the heavy feeding of the insects did not completely dwarf and check the growth. In spraying with lime-sulphur, 1 part to 33 parts of water, an estimated 80 per cent of the psyllids were killed. The spray injured the growth of the plants and checked or stunted the development for about ten days. After that time the new growth started and the plant developed rapidly. Some of the psyllids were present but did not seem to injure the plants. No difference was observed on such plants as far as total yield at harvest time was concerned, over the check plants or those with no psyllids present. This work produces evidence to show that the psyllid was not at that time associated with the disease, and feeding did not completely stop normal development and production of fruit.

Symptoms of the Disease

On Potatoes: The symptoms of the disease on potatoes have been described by Richards (2) as being distinctly different from any of the previously described diseases of the potato. "The upward rolling or cupping of the basal portions of the younger leaves constitutes the most characteristic symptom of the disease. In the Bliss and the Cobbler this rolled portion becomes brilliantly colored, varying from light pinkish yellow to purple. The older leaves soon become involved, roll upward, turn yellow, and die. The auxillary buds are stimulated into activity, resulting in one or a combination of three

types of growth, thick, heavy shoots which may exceed in length that of the sub-tending leaf, aerial tubers, and rosettes of small and frequently highly colored leaves. In the latter stages of development, owing to the death of the first leaves, the plant may consist very largely of this second growth. This stimulated development is expressed in increased number of tubers in the soil and in the germination of the tubers formed prior to infestation. A second crop of vines may thus result. Tubers sprout immediately when placed in storage."

On Tomatoes: The first indication of the disease on tomatoes is the upward curling of the basal portion of the younger leaves. The cupped leaf margins soon turn from a light green to a purplish and finally to a brown color. As the disease develops the older leaves are affected and similar changes take place until the entire plant loses its normal color. The older leaves do not always drop off, and under greenhouse conditions often cling to the plant until all the healthy plants are through bearing. There is a noticeable dwarfing and checking in the growth of a diseased plant and this condition is accompanied by a stimulation of secondary sprout growth, usually at the top of the plant. The curled leaves are generally thick, woody, and brittle. The diseased plants are dwarfed to about half normal growth and generally do not produce fruit. Occasionally, blossoms are set and small fruit is formed, but these are of a pale yellow color, watery, and without flavor. The symptoms on tomatoes are very similar to those reported on the potato plant. The disease may apparently affect the plants at any stage of growth, although the plants seem to be most susceptible in the early growth stages.

On Peppers, Eggplant, and Jerusalem Cherry: The disease on peppers and on the ornamental Jerusalem produces the characteristic upward rolling of the leaves, slightly dwarfs the plant, and prevents a normal fruit set. The common eggplant was not found to be a favored food plant. There were no severe symptoms of the disease and the plant was not materially injured.

Transmission of the Disease

Review of Literature: Since the outbreak of the disease there have been two main points of contention concerning its cause. The first is that the nymphs of the insect while feeding on the leaves inject or leave a toxic secretion which is injurious to the plants; the second is that the insect transmits a so-called virus. In all cases it has been associated with the feeding of the nymphs of the common tomato psyllid. Richards (2) in his report of the disease on potatoes in Utah has found it to be induced by nymphs. By confining the nymphs in gauze bags to a single older, or lower leaf, the first symptoms of the disease were produced in nine days in remote portions of the plant. However he states, "The nature of the substance, whether a poison or virus, injected into the plant during the feeding of the insect has not been determined."

Non-Viruliferous Insect Studies

In the cooperative work with Mr. L. B. Daniels, assistant entomologist, nymphs were collected from healthy potato plants in the horticultural greenhouses and were transferred to tomato plants in the Entomology greenhouse. The nymphs were permitted to feed on healthy tomato plants until they reached the full adult stage; The plants were not materially injured by feeding and produced a normal fruit set. There was a heavy infestation, yet there were no characteristic symptoms of the disease apparent.

Hatching of Psyllid Eggs

A study was made to obtain information in regard to the transmission of the disease. Accordingly, 20 eggs laid by the common tomato psyllids, under caged conditions, were removed from the leaves of the diseased tomato plant and placed on moist blotting paper in a petrie dish, and hatched artificially. As soon as hatched, the nymphs were placed on healthy tomato plants eight weeks old and permitted to feed. In this observation only two plants were used in the insect cage, and eight nymphs were placed on the growing portion of the younger leaves of each plant. Check plants were grown in another insect-proof cage.

The plants on which the psyllid nymphs were feeding failed to produce the disease. The nymphs fed until reaching the adult stage, and in no case did the plants show the characteristic symptoms of the disease. The plants were taken out of the cage after the feeding of nymphs and set out in larger pots. The plants developed to practically normal size and produced blossoms and fruit. The period that the plants were grown in the shade, while in the insect cages, prevented completely normal growth. This work indicates that the disease is not transmitted through the eggs of the insect.

The second check on the above phase was made for additional evidence. This time eggs were again taken from leaves of diseased plants and hatched artificially. Twenty-seven eggs were hatched, and eight nymphs were placed on each of three healthy plants, and carried in insect-proof cages in the greenhouse as previously described. Check plants were carried as before. The nymphs fed on the plants until they reached the adult stage. The three plants grew normally and were not affected with the disease.

Studies With Viruliferous Insects

Potatoes: Certified potatoes of the Irish Cobbler variety were placed in pots May 17 in the insect-proof cages. The plants were grown entirely under the cages which were placed outdoors in an isolated location. Six plants were grown in each cage, and to one set of plants numerous nymphs from diseased plants were transferred for feeding. The plants in the other cage were grown as checks and were free from insects of any kind. The nymphs were small when transferred on September 10, and the potato plants were also small, about four inches in height. On September 18, after eight days of feeding,

the first symptoms of the disease were observed on the young leaves of three of the plants. The three remaining plants showed similar indications two days later. There was a noticeable decrease in growth on all of the infected plants, when compared with the check plants in the adjoining cage. The secondary sprout growth was also quite marked on the diseased plants.

Tomatoes: Tomato plants grown under field conditions, but protected from all insects by plant protectors, produced a normal crop of fruit. Adjoining unprotected plants infected by psyllids were so severely damaged as to prevent a setting of the blossoms and fruit and were a complete loss.

Inoculation work was also carried on with tomato plants using the same caging methods under which the disease was produced with potatoes (Matchless variety) and similar results were secured.

In the case of tomatoes, three sets of plants were used and the insects transferred when the plants were 7, 9 and 12 weeks old. The insects were placed on the plants on the same date, and the nymphs were nearly the same size. Six insects in the early nymph stage of growth were placed on each plant of the same age group.

Age of Plants	Date Insects Were Placed on the Plants	No. of Days for First Symptoms to Show
7 weeks	Sept. 5	6
9 weeks	Sept. 5	10
12 weeks	Sept. 5	10

The smaller plants were the first to produce indications of the disease in the form of curling of the lower leaves.

Inter-Transmission of the Disease Between Hosts

Psyllid nymphs which had been feeding on diseased tomato plants, were transferred to healthy potato vines, and the disease was thus transmitted to potatoes. The reverse was also true and the disease transmitted from potatoes to tomatoes.

Nymphs which had been feeding on diseased tomato plants were likewise transferred to healthy peppers, to Jerusalem Cherry, and eggplants. The disease was transmitted to them, however, they did not show the severe injury that is characteristic of the disease on the tomato and potato.

Artificial Inoculations

A portion of a diseased tomato plant was removed, crushed, and the juice extracted and filtered. The inoculations were made with a needle according to the generally accepted methods. Twenty-two inoculations were made on healthy plants, about 12 weeks old. The needle inoculations were made at different locations on the plant. In no case did any of the plants so inoculated show indication of the disease. There may be a certain time required for the proper incubation of the so-called virus, within the body of the nymphs before it can be transmitted to a plant. Needle inoculation was not a successful means of transmitting the disease.

Variety Susceptibility of Tomatoes

During the 1928 growing season on the college experimental gardens, the tomato variety work was a complete failure due to the psyllid-yellows disease. There was 100 per cent infestation, and the disease destructively injured all of the unprotected plants. There was no difference in variety resistance. The following varieties were in the trial plots:

1. Bonny Best
2. Matchless
3. Livingston Globe
4. Landreth
5. Chalk's Early Jewel
6. Livingston's Oxheart
7. Adirondack Earliana
8. Ideal Forcing
9. Grand Rapids Forcing
10. Wayahead
11. Crimson Cushion
12. John Baer

All of the above varieties were susceptible and no difference in yields could be recorded. There was some variation in the symptoms.

Discussion

A preliminary report on the psyllid-yellows disease is presented to re-direct attention to the destructive nature of the disease and to summarize briefly the studies and observation made to date. In all cases so far reported the disease has been found to be associated with the common tomato psyllid and is shown to be most destructive on potato and tomato crops. While definite symptoms of the disease were found on pepper plants, eggplants, and the Jerusalem Cherry the disease was not so destructive on them.

The early control work has shown that the insect can be controlled to a certain extent by the use of lime sulphur spray applied at the rate of 1 part to 33 parts water. The scale-like nature of the nymph, its habit of feeding on the under side of the leaves, and the cupping or rolling of the leaves, act as a further protection, which makes their control difficult. It is also necessary to use a strong spray mixture to kill the nymphs, which makes control difficult because the tender foliage plants such as the tomato are easily injured. Even with very careful spraying it is difficult to kill a high percentage of the nymphs; since a single nymph can transmit the disease, the question of control is a difficult one. The early control work on tomatoes produced a checking of the growth of the plant where lime sulphur sprays were used, however the plants recovered and yielded a normal crop. This is true where the yellows disease is not present. If such plants are affected by the disease and spraying is resorted to, there will not be the recovery in growth or the production of a normal yield of fruit even though the psyllid nymphs are killed.

The symptoms of the disease are distinctly different from the other common diseases of solonaceous plants, although there is some variation in the symptoms on the different varieties of the potato and the tomato. The outstanding characteristic symptom is the upward curling or cupping of the leaves and partial reduction in the growth rate.

In the observation made with the viruliferous nymphs also under cage conditions, the disease was readily transmitted to healthy

tomato and potato plants in a short time. This indicates that the psyllid nymphs were instrumental in transmitting the disease. The disease was also transmitted to other solonaceous plants and characteristic symptoms produced; however, such crops did not show the severe injury that is produced on tomato and potato plants.

The work with non-viruliferous nymphs indicates that their feeding alone does not produce the symptoms of the disease. The preliminary observations were checked by the hatching of the eggs laid by the viruliferous insects on diseased plants, grown under caged conditions. The eggs were hatched artificially under sterile conditions and the nymphs were carefully placed on healthy plants and permitted to feed for the first time on the growing portions of the plant. The results indicate that the virus is not transmitted through the eggs of the insect, and that the feeding of the nymphs does not injure the normal growth of the plant. When a single viruliferous nymph was placed on a plant there was ample time for the symptoms to appear. However, such plants made practically a normal growth. A second check produced the same results.

From the transmission studies the preliminary evidence indicates that the disease may be of a virus nature, and is transmitted by psyllid insects. In all cases the disease has been found directly associated with nymph feeding, and symptoms can be readily produced by transmitting viruliferous nymphs to healthy plants. Artificial inoculation of the extracted juice from a diseased plant, by means of needle injections did not seem to be a satisfactory method of transmission.

The varieties of tomatoes under observation were equally susceptible to the disease. The plantings were in duplicate and there was practically no difference in the resistance of individual plants within a variety to the disease.

Acknowledgments

The writer wishes to express his appreciation to Mr. C. H. Metzger, Associate Horticulturist, for information furnished on the losses and distribution of the disease on the Western Slope of Colorado and to Dr. E. P. Sandsten for helpful suggestions.

Literature Cited

1. Linford, M. B. New or little known diseases: Potato psyllid yellows disease. Plant Disease Reporter Supplement 59:95. 1928.
2. Richards, B. L. A new and destructive disease of the potato in Utah and its relation to the potato psylla. Proc. Potato Assoc. of Amer. 14:94. 1927.
3. Essig, E. O.—The tomato and laurel psyllids. Jour. Econ. Ent. 10:42. 1917.

The Period of Blossom Bud Differentiation in the Baldwin and McIntosh Apples

By E. J. Rasmussen, *University of New Hampshire, Durham, N. H.*

THE period of blossom bud differentiation in the apple appears to vary considerably in different localities. E. S. Goff (5, 6, 7) one of the earliest scientific workers on the subject, found indications of flower buds from June 30 to Oct. 1, a period of three months. Drinkard (4) found evidence of a prolonged period of differentiation from June 20 to late summer. Bradford (2) shows evidence of flower bud formation in the Yellow Newtown from early July to late August. Black (1) examined buds collected July 3 and July 20, and observed no indication of blossom buds. Tufts and Morrow (9) give the date of June 11 as the first indication of flower buds in the Gravenstein. Kirby (8) found blossom buds forming from July to the middle of September.

In the work reported here, the total number of buds collected at each date was 96, a sufficiently large number, it was thought, to give a reasonably accurate estimate of the percentage of spurs which had initiated blossom buds on each date. The period during which successive samples showed significant increases in the proportion of blossom buds was short and definite. In the Baldwin in 1928 most of the blossom buds appeared between July 29 and Aug. 14, a period of 17 days, in 1929, from July 19 to Aug. 2. In the McIntosh, blossom bud differentiation occurred over a similar period, but about 10 days earlier.

In 1928, eight 40-year-old Baldwin apple trees in their "off-year" on the Horticultural Farm were selected from which to pick buds. Two of the trees were in a clean cultivated plot which was sowed to buckwheat about July 15; two were in a plot receiving similar treatment except that the trees were fertilized in May with 5 pounds of sodium nitrate each; three were in blue grass sod and received a spring application of 5 to 7 pounds of nitrate of soda each; one was on the border of a blue grass sod plot and a clean cultivated strawberry field. It received 10 pounds of sodium nitrate in the spring.

In 1929, eight different Baldwin trees were selected, because those from which the buds were picked in 1928 would be in the "on-year" and would not set many blossom buds. Four of these were in a clean cultivated plot, and four in a sod plot, all receiving sodium nitrate as a fertilizer.

From each tree, samples of three buds were picked from the following types of spurs: (1) Those on upper branches which had borne fruit the previous year or the year before, but which were not bearing the current year; (2) same as group 1, but on low branches which could be reached from the ground; (3) non-fruiting spurs on upper branches on three-year-old wood; and (4) same as group 3, but on low branches.

The McIntosh buds were collected in 1928 from twenty-five 15-year-old trees in the Gowen Bros. orchard at Stratham. These trees blossomed heavily in the spring of 1928 but set only a very

light crop of fruit. This was likely due to unfavorable weather for pollination. The trees, which were about 20 feet apart, were all in blue grass sod, and received a spring application of from 4 to 6 pounds of sodium nitrate per tree. Because of weather conditions favorable for scab development, many of the leaves were infected with the fungus early in the season.

Six buds per tree were picked, two from each of the following types of spurs: (1) New spurs formed during 1928 on wood which originated in 1927; (2) spurs on three-year-old wood which blossomed for the first time in 1928 but did not set fruit; and (3) spurs on wood older than three years, which had either previously borne fruit or blossomed. All of these spurs were non-bearing in 1928, but a few had produced blossoms which failed to set. All the buds were collected from limbs that could be reached from the ground. The total number collected at each date in the case of the McIntosh was 150.

In 1929, twenty-five different trees were selected in the same orchard from which to collect buds. The selection of buds from spurs of the types in groups 2 and 3 was continued, and in place of group 1, non-bearing spurs on 1927 wood were selected.

The buds were collected at 7- to 10-day intervals on the dates shown in Table I. Care was taken to pick buds from all sides of the trees at each picking in order to insure as representative a sample as possible. Only the largest buds, those most likely to form flower buds, were collected. Immediately after picking, the leaves were removed, the buds wrapped in damp cloth, and taken to the laboratory where the outer bud scales were removed. The buds, with 1/8 inch of woody tissue attached, were preserved in an alcohol-formalin-acetic acid solution until sectioned.

The Baldwin buds collected in 1928 were embedded by the combination celloidin-paraffin method as outlined by DeZeeuw (3) which is an abridgement of the Kornhauser method. These buds were fixed to the slides with an albumen fixative, stained with Delafield's hematoxilin, and examined under a microscope. The low power objective and a 10-x ocular gave sufficient magnification to bring out the different parts of the bud. The buds were stained to the desired color and dehydrated in an alkaline, alcoholic solution which gave a blue stain to the cell walls and the meristematic area, making it easy to distinguish the different tissues in the bud. Double staining with safranin proved to be of no advantage.

Because the embedding method required so much work for the large number of buds to be examined, a more simple method was sought. It was found that the buds could be held with the fingers in a piece of split elder pith and suitable sections cut with a microscopic section cutter or a safety razor blade. The sections were mounted in water on a slide, covered with a cover glass, and examined under a microscope. The McIntosh buds collected in 1928 and 1929, and the Baldwin buds collected in 1929, were sectioned in this manner.

This relatively rapid method gave satisfactory results when the sections were cut as thin as possible. It was a little more difficult to distinguish the very first appearance of differentiation. After the flower buds were a few days advanced, however, they could easily

TABLE I—PER CENT OF BLOSSOM BUD FORMATION.

1928						1929					
Baldwin			McIntosh			Baldwin			McIntosh		
Date	Number Buds Examined	Per cent Blossom Buds	Date	Number Buds Examined	Per cent Blossom Buds	Date	Number Buds Examined	Per cent Blossom Buds	Date	Number Buds Examined	Per cent Blossom Buds
July 8	96	0	July 18	150	0	July 12	96	0	July 8	75	0
15	96	0	29	150	16.0	19	96	11.4	17	75	74.6
23	96	0	Aug. 9	150	39.3	29	96	70.9	'26	75	73.3
29	96	0	19	149	40.2	Aug. 2	96	87.5	Aug. 5	75	76.0
Aug. 7	96	19.7	25	147	42.8	9	96	87.5	13	74	83.7
14	96	32.2	Sept. 5	149	52.3	17	96	95.8	25	75	76.6
20	95	33.6	21	148	45.2	25	96	86.0	30	75	88.0
25	94	27.6	30	150	38.6	29	96	89.5			
Sept. 4	92	38.0	Oct. 12	150	40.0						
13	91	43.9	26	150	42.0						
21	94	27.6									
27	92	34.7									
Oct. 6	95	41.0									
13	93	34.4									

be distinguished from leaf buds. Plates I and II show the development of the Baldwin buds collected July 29, Aug. 7, Aug. 14, and Aug. 20. It is not difficult to distinguish a flower bud of less development than that collected on Aug. 14 from a leaf bud similar to those collected July 29, when the buds were sectioned free-hand. With such rapid development only the very first two or three days of differentiation could be overlooked.

The photomicrographs were made with a Zeiss microscope equipped with a number 2 compensating ocular and a 16 mm. apochromatic objective. A Nernst lamp, which has a spectrum similar to that of sunlight, was used for illumination. A Visual Luminosity Ray Filter was placed above the diaphragm to decrease the intensity of the blue rays. The pictures were taken on Cramer's slow isochromatic dry plates.

Correction for the curvature of the lens in the microscope was made by first focusing to get a sharp image of the center of the bud on the ground glass. Then the dial on the fine adjustment was read. Next the focus was readjusted to obtain a sharp image on the outer edge of the bud, and the dial again read. The plate was exposed for one-half the required time at each reading. This gave a better picture throughout than when one focus only is used.

In this work, the thickening of the meristematic area, or the crown of the bud, the elevation of this area, with the concurrent advance of the fibrovascular, and pith tissues is considered to be the first indication of differentiation of flower buds. The changes cause the pith area to become somewhat triangular in shape as viewed in a longitudinal section, rather than semi-circular as is characteristic of the undifferentiated bud. These are practically the same criteria as those which Goff (5), Kraus (9) and Bradford (2) describe. The broadening of the floral axis and development of protuberances described by other investigators was not found in this case to be a dependable indication of a blossom bud. These protuberances may develop into leaves as shown in Fig. 6 by camera lucida outlines of a series of buds.

Kirby (8) does not state definitely what he considers to be the first indication of floral organs, and some camera lucida drawings give the impression that leaf primordia may in some cases have been confused with the earliest stages of flower development. If such an error were made it would create the impression of a very extended period of flower initiation.

A typical leaf bud is shown in Fig. 1, Plate I. Prior to August 7, 1928, and July 19, 1929 all the buds collected of the Baldwin variety were of this character. On August 7, 1928 and July 19, 1929, the first indication of flower bud formation, as previously described, and shown in Plate I, Fig. 2, was observed in 19.7 and 11.4 percent of the buds respectively. A few buds of this character were found as late as August 14 in 1928 and August 2 in 1929. Thereafter no early stages of development were found. In the McIntosh variety the first indication of blossom buds was observed in 1928, July 29, and in 1929, July 17, 16 and 74.6 per cent respectively. No early stages of development were found after the August 9 sampling in 1928, and after the July 17 sampling in 1929. There is, according to the graphic

Plate I

Fig. 1. Baldwin, July 29, 1928.

Fig. 2. Baldwin, August 7, 1928.

PLATE II

FIG. 3. Baldwin, August 14, 1928.

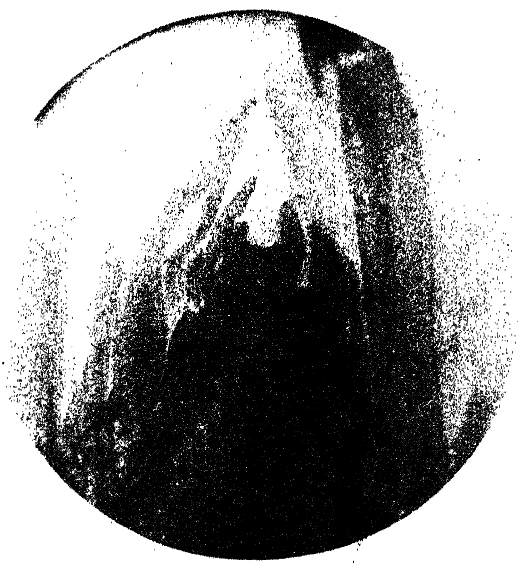


FIG. 4. Baldwin, August 20, 1928.

representation of these results shown in Fig. 5, a little formation of flower buds from August 9 to August 25 in 1928. This is, however, likely due to the error of random sampling, since no early stages were observed in the August 19 and August 25 samples.

Table I shows that there is considerable variation in the per cent of flower buds found in the different samples after the majority of flower buds were formed. This may perhaps be grasped most clearly by reference to Fig. 5 in which the per cent of flower buds found on the different dates is shown graphically. While these variations are large, a line drawn along the medium points shows no significant upward trend.

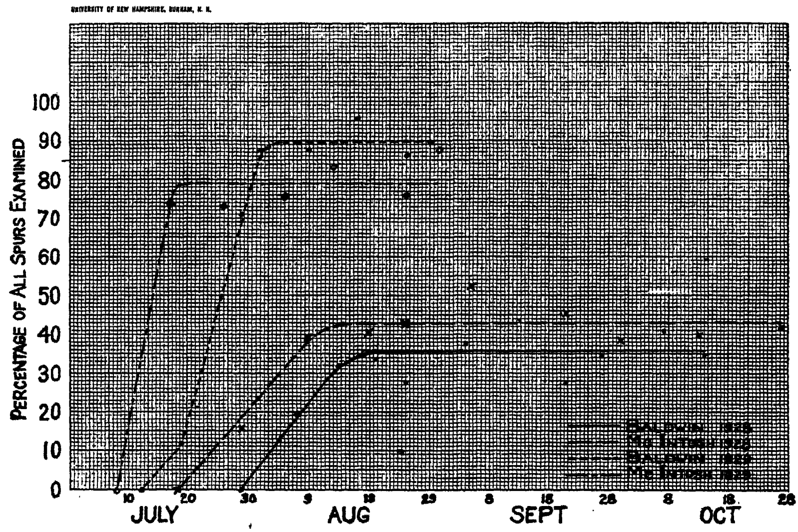


FIG. 5. Percentage of blossom bud differentiation in the McIntosh and Baldwin varieties, 1928 and 1929.

The error due to random sampling when 75 or more buds were collected at a time is larger than was anticipated, although only the largest buds, those most likely to form flower buds, were selected. The failure of the large buds to show a higher percentage of flower buds in 1928, indicates plainly that size and outward appearance of the buds are of little value as an indication of flower bud formation. The higher per cent of blossom buds in the 1929 collections may be due to selection of buds with six or more leaves, or to more favorable weather conditions. Some investigators think that fruit bud formation is a result of a check in growth, as is evidenced by ringing and defoliation experiments. In 1928 the summer was rainy with little sunshine, while in 1929 there was a prolonged drought during part of June and July, with an abundance of sunshine. By July 3 practically all terminal growth had ceased on the Baldwin trees, and by July 8 on the McIntosh trees in 1929. The development of the flower buds in each collection was uniform. In most cases there was less variation between buds in individual samples than there was in buds of

different successive samples, and in no instance was there as great a variation in individual samples as in those taken two weeks or more apart. In the later collections the buds were clearly either advanced stages of flower buds or else leaf buds. The finding of no early stages of differentiation in the later collections seems to corroborate the statistical data and give further proof that the period is not prolonged until frost in the fall, as some investigators have concluded.

If we consider that every leaf bud is potentially a flower bud and that the formation of flower buds is caused by a check in growth, different localities would vary in the time and period of fruit bud differentiation, and even the same locality may vary considerably from year to year, depending on weather conditions. This is evidenced by the results of the past two years with Baldwin and McIntosh in this locality.

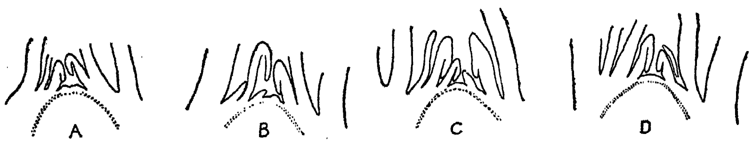


FIG. 6. Development of leaves from protuberances on crown of bud.

In the Baldwin variety there was apparently no difference in the blossom bud differentiation in the different types of spurs, as was found by Bradford (2) or on trees grown under different cultural methods, as was observed by Kirby. (8)

In the McIntosh variety in 1928 the buds on spurs which originated on 1927 wood showed the first appearance of blossom buds 10 days later than that of older spurs. In 1929 there was no difference in the time that flower buds were first formed. This difference is likely due to the delayed differentiation in buds collected from the previous year's wood. In 1929 this type of spur was not collected because a higher percentage of blossom buds were desired than was found in this group.

LITERATURE CITED

1. BLACK, C. A. The nature of the inflorescence and fruit of Pyrus malus. N. H. Agr. Exp. Sta. Tech. Bul. 10:519. 1916.
2. BRADFORD, F. C. Fruit bud development of the apple. Ore. Agr. Exp. Sta. Bul. 129:1. 1915.
3. DE ZEEUW, RICHARD. The value of double infiltration in botanical microtechnique. Papers Michigan Acad. Sci. 1:83. 1923.
4. DRINKARD, A. W. Fruit bud formation and development. Va. Agr. Exp. Sta. Rept. 1909–1910:159.
5. GOFF, E. S. The origin and early development of the flowers in the cherry, plum, apple, and pear. Wis. Agr. Exp. Sta. Rpt. 16:289. 1899.
6. ———. Investigation of flower buds. Wis. Agr. Exp. Sta. Rpt. 17: 266. 1900.
7. ———. Investigation of flower buds. Wis. Agr. Exp. Sta. Rpt. 18:304. 1901.
8. KIRBY, R. S. A study of the formation and development of the flower bud of Jonathan and Grimes in relation to the different types of soil management. Proc. Ia. Acad. Sci. 35:265. 1918.
9. KRAUS, E. J. Gross morphology of the apple. Ore. Agr. Exp. Sta. Res. Bul. I, Part I.
10. TUFTS, W. P., and MORROW, E. B. Fruit bud differentiation in deciduous fruits. Hilgardia 1:1. 1925.

Relation of Blossom Formation in the Concord Grape to Current Season Conditions

By N. L. Partridge, *Michigan State College, East Lansing, Mich.*

NUMEROUS papers from several authors have correlated grape cane growth in one season with fruitfulness in the subsequent season. The purpose of this paper is to present considerations indicating that though growth in one season predisposes a given cane to high, low or medium fruitfulness in the next season, there is also a distinct influence exerted by conditions in the spring, quite apart from those of the preceding season, which has a marked effect upon the number of blossom buds produced in the cluster.

The fruiting cluster of the grape is morphologically a modified tendril. The development of a tendril into a blossom cluster depends upon the internal condition of the plant. Clusters are found with "shoulders" or a large secondary cluster on one side, without a shoulder, with a tendril instead of a shoulder, and tendrils are often found with a few blossom buds on their sides. Which of these types is developed depends upon the same conditions that determine the development of clusters at all. As has been pointed out by Colby (1), the largest blossom cluster is usually the one that is developed closest to the base of the shoot, the others being progressively smaller. Sometimes the second cluster of a group of three may surpass the basal cluster in size, or other irregularities may be found. The distal bunch is usually supplied with a tendril and is only rarely found with a shoulder.

There are certain nodes at the base of the shoot that rarely bear anything but blossom clusters. If no blossom cluster is produced at these nodes, usually no tendril is produced either. The usual position of blossom clusters is at nodes 3, 4, 5, and 6 of the spring shoots on the Concord grape. In a group of 26 shoots with from one to four blossom clusters apiece, clusters were produced at node 3 on seven shoots, at node 4 on 26 shoots, at node 5 on 23 shoots and at node 6 on ten shoots. In numbering nodes, the first node is within a millimeter or two of the base of the shoot and rarely produces a small leaf, with a blade usually not exceeding one cm. in length, although it produces a bud. Neither tendrils nor blossom clusters have been observed on nodes 1 or 2.

As was pointed out by Goff (2) the primordia of the blossom cluster may be observed by sectioning the dormant bud. There is no differentiation of blossom buds, the primordium is merely a mass of heavily nucleated thin walled cells from which a cluster of bloom will be developed the following spring under favorable conditions. The time at which these primordia develop has not been determined with any accuracy although there is some evidence that some primordia are developed by midsummer.

It is possible to force the development of the normally dormant bud in midsummer by pinching off the tip of the growing shoot and removing the laterals which are normally found at each node. These shoots produce blossom clusters as is shown in Fig. 1. Owing to the

fact that two or three blossom clusters are produced on these shoots, in the position normal to regular fruiting, it is thought that primordia were present in these buds, although no microscopic examination was made of the buds at this season. These clusters did not have as many blossom buds as average-sized spring clusters. When more or less abnormal blooming occurs, as described later, there is usually but a single blossom cluster to the shoot. Though some primordia may be present in midsummer, it is by no means certain that other primordia may not be developed in these same buds later in the summer or perhaps even early the following spring. There is little doubt, however, that the vast majority of primordia which will produce bunches with shoulders or clusters without tendrils are present in the dormant buds.

It is not impossible for a cluster of blossoms to develop without a corresponding primordium being present in the dormant bud. This situation is illustrated by the development of blossom clusters and fruit on lateral shoots as illustrated in Fig. 2. This condition is infrequent in the Concord, although is it frequent enough so that some lateral fruiting is observed every season. Two different kinds of growing points are produced at nearly all the nodes of normal Concord shoots. One of these develops into the dormant bud which will resume growth the following spring under favorable conditions. The other is the lateral of the current season's growth. Unless growth conditions are favorable it will not exceed a length of a cm., an abscission layer will develop and the lateral will drop off. Examination of the dormant cane shows that there are two scars at most buds, one below the bud which is the leaf scar, and one to the side of the bud where the lateral was produced. The scar of the lateral is wanting where conditions were favorable for its growth and lateral scars are also lacking at the first two or three nodes on each cane. Scars are sometimes wanting on canes where the growth was very weak.

The laterals which produce blossom clusters are making vigorous growth at the time the blossom buds are produced and observation shows that in practically every instance some accident has removed the terminal growing point from the shoot. Not all the laterals fruit, even under these conditions. A group of 30 fruiting laterals in 1929 produced one bunch each in 28 cases, 25 clusters at the second node and 3 clusters at the third node. Two of the laterals produced two clusters each, one at the second and one at the third node in each instance. Lateral fruiting occurs on lower numbered nodes than is the case with shoots growing from dormant buds.

In 1923 this condition was quite common in the experimental vineyard at Lawton, Michigan. There was even some fruiting on main shoots at an unusually great distance from the base of shoots that did not have blossom clusters at the base of the cane. The clusters appeared in the vicinity of the tenth node and it is certain that there were no corresponding primordia present in the dormant buds because of the undifferentiated condition of this portion of the bud. The vines on which this type of fruiting occurred had produced a very large crop the preceding season and had made very weak shoot

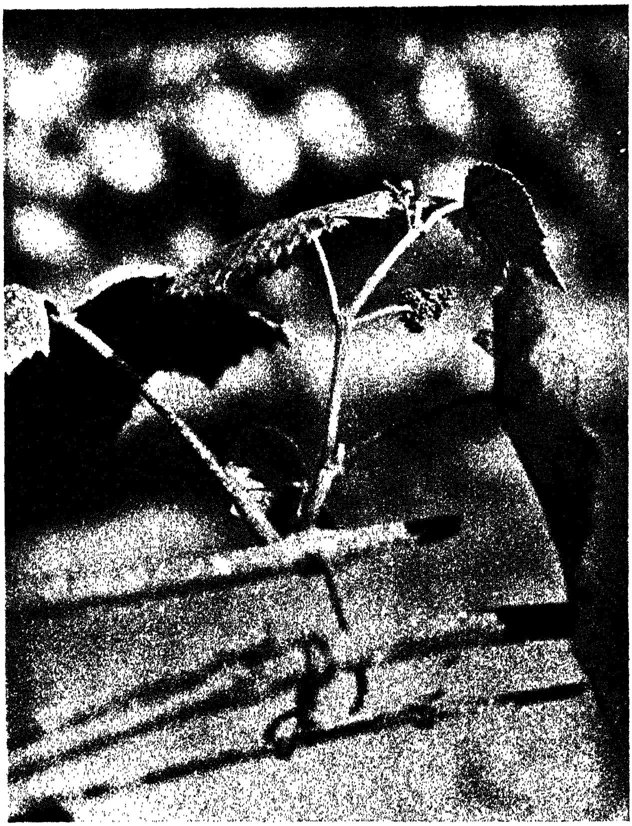


FIG. 1. The blossom clusters are on a shoot from a normally dormant bud which was forced into growth a season ahead of time. Photo Aug. 25, 1923. Shoot commenced growth early in August.

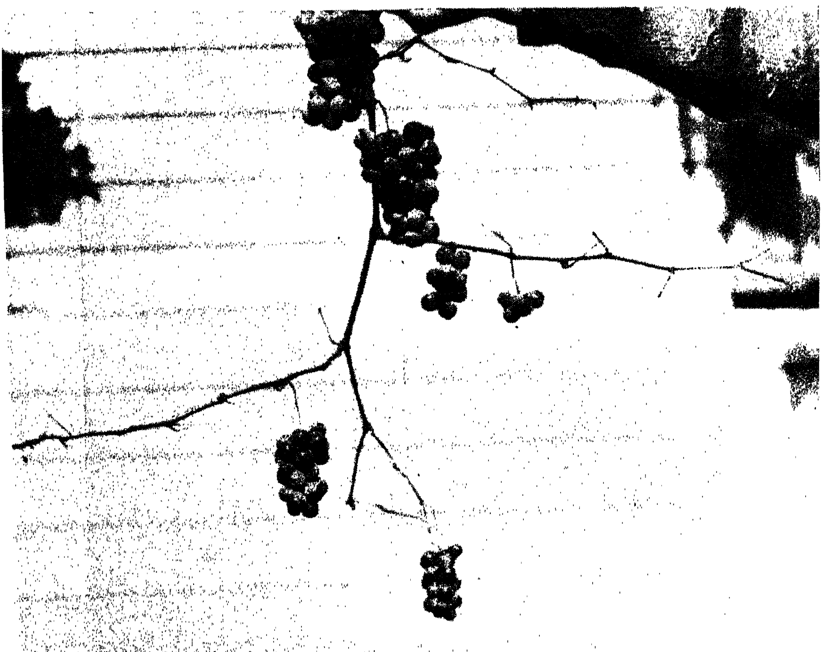


FIG. 2. Fruiting on laterals of the Concord grape. The four small clusters have been produced on laterals the two large ones on the primary shoot. Photo made in October 1929.

growth that year, so the canes left at pruning time were of the weak, normally low-productive type. The pruning was quite severe with the result that the shoot growth became quite vigorous after growth commenced.

The amount of the crop obviously depends upon the number of the bunches and their size. The number of blossoms that develop in any cluster is entirely dependent upon the nutritional conditions in the growing primordium in the spring. If the food supply is deficient, the clusters will be small and the clusters will be progressively larger the more favorable the condition may be. The development of a large primordium in the dormant bud is, of course, dependent upon presence of a good supply of food material at the node. Nutritional conditions consequently are usually favorable for development in the spring. The smaller size of the clusters farther from the base of the shoot is perhaps caused by the later and smaller development of these primordia, as has been suggested by Colby (1), or is due to their location in a less favorable environment during their spring development.

The number of blossoms that develop in a cluster is largely dependent upon growing conditions in the spring, which determine how the stored plant food is to be utilized and which determine the amount of carbohydrates that may be produced in the young leaves. It has been shown elsewhere (3) that the fruiting of a cane of the Concord grape is related also to the external characteristics of the dormant cane. This relationship extends to the weight of the fruit clusters as well as to the number of bunches developed per shoot. This fact is strong evidence that the large clusters develop from overwintering primordia, for the external characteristics of the cane are merely an expression of the manner in which shoot growth took place the preceding season. The association of large bunch size with the largest number of bunches per shoot is not absolute, although the shoots with the largest number of bunches usually produce bunches of good size. This appears to be an indication of a tendency for a cane to maintain the favorable or unfavorable nutritional conditions which characterized the shoot the preceding season. If growth conditions at that time were favorable for primordia development there was also a larger store of carboyhdrates laid down in the vicinity of these nodes which are more likely to produce well as has been shown by Schrader (4). This supply of food material is not only available to supply the primordia which are developing and to aid in cane "maturity" but will also give the young shoot a good supply of food material available early in the spring which will promote a vigorous growth.

There is a positive correlation between the vigor of shoot growth and the number of blossom buds differentiated in the cluster. In a group of 26 canes whose length ranged from 17 to 117 cm. on June 19, 1928, a certain correlation is observed between length of shoot and the number of blossom buds differentiated in the cluster. There are many irregularities in the number of blossoms developed owing to the small size of the group, and it is also probable that favorable growth conditions merely present opportunities for full realization

of potentialities within each bud. However, unless conditions in the spring permit the full development of the primordium, the blossom cluster will not reach full size. The number of blossom buds differentiated in the largest cluster (which was the basal cluster on each cane) on the seven shoots ranging from 17 to 29 cm. in length averaged 75, on the four shoots from 40 to 59 cm. it was 87, on the ten shoots from 63 to 81 cm. it was 137 and on the five shoots from 93 to 117 cm. it was 130. Bloom was over and the grapes were set within a month of this date.

Whether the correlation between the size of the blossom cluster is closer with the cane characteristics which represent growth conditions the past season or is more nearly associated with the early season shoot growth is still an open question, owing to the marked correlation which exists between these two sets of growth conditions under normal vineyard management. They seem to move together in the Concord grape. The number of bunches is probably more closely associated with the characteristics of the cane than with those of the shoot and the size of the blossom cluster is more closely tied up with the characteristics of the shoot growth than that of the cane. Number of bunches and size of bunch both affect total yield. Which one of the two is the more important in determining the crop may depend upon the normal size of the bunches of the variety. In those in which the bunches are small, their number is probably of greater significance, and in those varieties in which the bunches can attain large size, size of bunch is probably the more important. However, the data presented show that vineyard conditions in the spring have a material effect on crop production in the average Concord vineyard.

Literature Cited

1. Colby, A. S. and L. R. Tucker. Growth and fruit production studies in the grape. Am. Soc. Hort. Sci. Proc. 25: 210–216. 1929.
2. Goff, E. S. Investigations of flower buds, Wis. Sta. Rept. 1901:315. 1902.
3. Partridge, N. L. The fruiting habits and pruning of the Concord Grape. Mich. Agr. Exp. Sta. Tech. Bul. 69. 1925.
4. Schrader, A. L. The Concord Grape. Pruning and chemical studies in relation to the fruiting habits of the vine. Md. Agr. Exp. Sta. Bul. 286. 1926.

Flower Counts of the Dunlap Strawberry Plant

By J. C. Schilletter and H. W. Richey, *Iowa State College, Ames, Ia.*

THERE is very little experimental evidence on the influence of thinning the younger strawberry plants from the clons. Data were lacking on the influence of the time and the amount of thinning of these younger plants on the number and size of berries. With this problem in mind records were taken to determine the relation existing between the position of a plant on a runner series and the yield of fruit of this plant, and also to determine the relation existing between the age of the plant and its yield. It was assumed that the number of flowers produced by the plants would be a satisfactory indication of the yield of fruit.

On April 25, 1928, 80 uniform Dunlap strawberry plants were selected and set 4 feet apart in rows 5 feet apart in a fertile sandy loam soil. The plants were placed under irrigation in order that they might not suffer in case of protracted dry periods.

During the growing season of 1928, all flowers were removed from the young mother plants as soon as they were visible. The plants were kept free of weeds and were cultivated at least once each week. They were watered on April 25 at the time of planting, on June 3, and also on August 6. The amount of water applied approximated one quarter inch of rainfall with each irrigation. Each individual mother plant was limited to 5 unbranched runner series. All other plants were removed as soon as noticed. By a runner series is meant the runner plants in a single connected string of plants arising from the mother plant.

A record was kept of each individual runner plant. As a new plant showed the first white root knobs it was considered as set and was fastened to the ground by means of a Greening pin. An oat straw mulch was applied November 15, 1928, and was removed April 15, 1929.

TABLE I—Average Number of Flowers on Runner Plants at Different Positions on the Runner Series.

Number of Plants Counted	Percentage Total Plants	Position on Runner Series	Total Number Flowers	Av. Number Flowers per Plant	Percentage Total Flowers
25	4.5	M. P.	5473	218.12	10.34
74	13.5	No. 1	8764	118.43	16.56
75	13.6	No. 2	8558	114.10	16.18
72	13.1	No. 3	9003	125.04	17.02
71	12.9	No. 4	8273	116.52	15.64
70	12.7	No. 5	6369	90.98	12.04
61	11.1	No. 6	3289	53.91	6.21
48	8.7	No. 7	2133	44.44	4.03
30	5.4	No. 8	702	23.40	1.33
17	3.09	No. 9	298	17.53	.56
5	0.9	No. 10	45	9.00	.09
548			52907		

On June 13, 1929, after all flowering had ceased, 25 representative mother plants and 84 runner series were selected for the purpose of

counting the number of flowers produced. These gave a total of 548 plants. Many of these plants had over ripe berries, and also flowers which had not matured and were quite dry. The total number of flower stalks and flowers produced was counted regardless of condition.

Table I shows the relationship existing between the yield of a plant and its position on the runner series. It will be observed that the 548 plants yielded a total of 52,907 flowers. The number of plants counted at each position varies; however, the average number of flowers produced by each plant at each position gives one a good idea as to the yield of these plants at the different positions on the runner series. It will be noted that the mother plants averaged the greatest number of flowers per plant. Of the runner plants, the number 3s, or those that comprised the third plants to set on the various runner series, averaged the highest number of flowers per plant with 125. With the exception of the number 3 plants, there is a gradual decrease in the average number of flowers per plant from the mother plant through number 10. The mother and the first five runner plants comprised the area of greatest yield.

It is interesting to note that although the mother plants constituted only 4.5 per cent of the plants they produced 10.34 percent of the flowers. The number 3 runner plants, which averaged 13.1 per cent of the total number of plants, were the highest producers with 17.02 per cent of the total yield of flowers. The number 10 runner plants comprised only 0.9 per cent of all the plants and produced only 0.09 per cent of the flowers.

A very striking fact is shown by adding the productions of all the plants including the mother plant through the number 5s. The plants occupying this area comprised only 69.8 per cent of all the plants, yet they produced 87 per cent of the fruit. Although plants from 6 to 10 inclusive on the various runner series comprised 29.19 per cent of the plants, they produced only 12.22 per cent of the fruit. Further evidence of the productivity of the first formed runner plants was shown by the fact that the runner plants 1, 2, 3, 4, and 5 totaled 65.8 per cent of the total plants formed and produced 77.44 per cent of all the fruit.

It should be realized that there is some overlapping as to the age of these plants. For example, some number 2 plants may be of the same age as the number 1 plants on another runner series.

Table II shows the relationship existing between the date of rooting of a plant, or its age, and its yield. This table also shows the percentage of the total runner production made during weekly intervals in relation to the yield of these same plants during the next season.

It may be observed in Table II that the mother plants, which were the oldest plants, averaged the highest number of flowers, with a production of 218 flowers per plant. Of the other plants those rooting during the week July 9 to 15 inclusive in 1928 were the highest producing plants in 1929, the fruiting year, averaging 120.17 flowers per plant. These plants were followed closely by those plants rooting July 16 to July 22 inclusive. The average number of flowers

per plant during the latter period was 120.03. The lowest average of 12 flowers per plant, was for the period from October 1 to 7 inclusive. The highest average yield per plant occurred on those plants which rooted during the earlier part of the season.

TABLE II—AVERAGE NUMBER OF FLOWERS ON PLANTS SETTING AT DIFFERENT WEEKLY INTERVALS.

Number Plants	Date of Set 1928	Percentage Runners Set 1928	Total Number Flowers 1929	Av. Number Flowers per Plant 1929	Percentage Total Flowers
25 M.P.	4/25		5473	218.92	10.3
1	5/28–6/3	.2	104	104.00	.2
0	6/4–6/10	—	—	—	—
3	6/11–6/17	.6	261	87.0	.5
10	6/18–6/24	1.9	1151	115.1	2.1
47	6/25–7/1	9.0	5545	111.59	10.5
37	7/2–7/8	7.1	4295	116.08	8.1
65	7/9–7/15	12.4	7691	120.17	14.5
58	7/16–7/22	11.1	6962	120.03	13.2
39	7/23–7/29	7.5	4679	119.97	8.8
46	7/30–8/5	8.8	5153	112.02	9.7
37	8/6–8/12	7.1	3564	96.32	6.7
55	8/13–8/19	10.5	3830	69.63	7.2
29	8/20–8/26	5.5	1366	46.10	2.6
34	8/27–9/2	6.5	1352	39.76	2.6
10	9/3–9/9	1.9	438	43.80	.8
19	9/10–9/16	3.6	584	30.73	1.1
8	9/17–9/23	1.6	167	20.87	.3
9	9/24–9/30	1.7	388	43.11	.7
6	10/1–10/7	1.1	72	12.00	.1
4	10/8–10/14	.8	51	12.75	.1
6	10/15–10/21	1.1	112	18.66	.2
548			52,907		

When weekly intervals are considered, it is again found that those plants rooting July 9 to 15 inclusive in 1928 are the most productive in 1929, yielding 14.5 per cent of the total number of flowers. The lowest producers are those rooting during the weeks of October 1 to 7 inclusive and October 8 to 14 inclusive. These plants produce in each of these periods only 0.1 per cent of the total number of flowers. It must be remembered, however, that 12.4 per cent of the total number of runners were set during the week of July 9 to 15, whereas only 1.1 per cent and 0.8 per cent, respectively, of the total runners were produced during the weeks of October 1 to 7 and October 8 to 14. A further survey of the table will bring out the fact that those plants that rooted during the earlier weeks of the season were the most productive.

When comparing intervals of approximately one month, it is found that from May 28, the date of setting of the first runner plant, to July 1, the number of runner plants that rooted amounts to 11.7 per cent of the total number of runners formed during the season, and that these plants produced 13.3 per cent of the total amount of fruit. During the next monthly interval, July 2 to 29 inclusive, the percentage of the total runners set, 38.1 per cent, was considerably over three times as great as that of the previous period, and these

runners produced over three times as much of the total amount of fruit, 44.6 per cent being produced. This period then was the period or interval of maximum production of runners and also was the period during which the most productive plants for 1929 were formed.

The next three 4-week intervals showed a gradual decrease, both in the number of runner plants formed and of the yield of the various runner plants. During the 4-week interval from July 30 to August 26 inclusive, 31.9 per cent of the total runners set, and produced 26.2 per cent of the total fruit. From August 27 to September 23 inclusive, 13.6 per cent of the total runners set, and these produced 4.8 per cent of the total fruit. The last 4-week interval, September 23 to October 21, was the period of lowest production of runners. Only 4.7 per cent of the total number of runners were set during this period and they produced only 1.1 per cent of the fruit.

Reviewing the data it is found that those plants which set their roots from June 25 to August 19 inclusive, during 1928 produced 78.7 per cent of the 1929 crop. It will be noted that 73.5 per cent of the total runners were set during this 60-day period. This was a very critical period then for the next season's crop. It is interesting to note that studies made by Richey and Schilletter with a much larger number of mother plants during this same season showed that 64.33 per cent of runner plants were set during this period. The plants rooting early in the season were by far the most productive. These data agree with those of Macoun (2) who recorded that the stolons formed in the earlier part of the season gave the largest number of flower stalks and hence the largest yield of fruit.

Although these data cover only one season, they are complete enough to enable one to make a few conclusions. They show that particular care should be used to secure a good stand of early-rooted plants rather than a good stand of plants rooting later in the season. They are indicative of the need for more attention being given to the time and amount of thinning given the late formed stolons.

Literature Cited

1. Richey, H. W., and Schilletter, J. C. Runner production in the Dunlap strawberry plant. Unpublished manuscript.
2. Macoun, W. T. Dominion of Canada, Dpt. of Agr. Div. Hort. interim Report of the Dominion Horticulturist for the year 1921. 48: 13. 1922.

Further Studies on the Fruiting Habit of the Worden Grape*

By W. F. PICKETT, *Kansas Agricultural College, Manhattan, Kansas.*

THIS report is the third to be made on the studies of the fruiting habit of the Worden grape at the Kansas Agricultural Experiment Station. These studies have dealt with the possible influence of cane diameter, at time of pruning, upon fruit production of the measured canes. In 1926, it was reported (1) that the coefficient of correlation between fruit production and cane diameter was .145 ± .086. In 1927 (2) the data showed a coefficient of correlation of .07 ± .09 between fruit production and cane diameter.

This investigation was continued in 1928 but a late spring frost killed nearly all the blossoms, hence the data were of little value. In 1929, the work was resumed. Forty-four vigorous Worden grape vines were selected for the experiment and were pruned according to the two-cane Kniffin system, each cane 18 buds long. Some of these vines had been used for the experiments of 1926 and 1927. The 44 vines used in 1929 produced an average of 14.4 pounds of fruit or at the rate of 7840 pounds per acre. The diameter of each of the 88 canes was measured mid-way between the fourth and fifth nodes, with a caliper graduated to sixty-fourths of an inch.

The cane diameter and yields for the years 1926, 1927 and 1929 are shown in Table I. Considering the data for 1929, the coefficient or correlation between cane diameter and fruit production is .076 ± .072.

The wood removed from each of the 44 vines at time of pruning was weighed and the weight of this wood was used as an index of the vigor of the vines. The coefficient of correlation between the amoune of wood necessarily removed to prune the vines to the two cant Kniffin system, each cane 18 buds long, and fruit production per vine is .501 ± 0.76. The data pertaining to this coefficient are shown in Table II.

TABLE II—WEIGHT OF PRUNING WOOD AND FRUIT PRODUCTION OF THE WORDEN GRAPE, 1929.

Weight of Pruning Wood per Vine in Pounds	Number of Vines Producing				
	101–150 Ounces Fruit	151–200 Ounces Fruit	201–250 Ounces Fruit	251–300 Ounces Fruit	301–350 Ounces Fruit
1.01 to 2.0	2	1	3	1	
2.01 to 3.0	1	6	7	4	1
3.01 to 4.0		2	3	0	2
4.01 to 5.0			1	5	2
5.01 to 6.0			1	1	1

From these observations, it is evident that the diameter of a Worden cane is a poor index of its fruit production and that, in

*Contribution No. 88, Department of Horticulture, Kansas Agricultural Experiment Station.

TABLE I—CANE DIAMETERS AND YIELD OF FRUIT OF THE WORDEN GRAPE.

Cane Diameters in Inches	1926		1927		1929		Summary of Three Years	
	Number of Canes	Average Weight of Fruit per Cane Ounces	Number of Canes	Average Weight of Fruit per Cane Ounces	Number of Canes	Average Weight of Fruit per Cane Ounces	Number of Canes	Average Weight of Fruit per Cane Ounces
9/64–12/64	6	92	9	122	8	88	23	101
13/64–16/64	21	87	14	111	32	105	67	101
17/64–20/64	25	98	15	109	21	116	61	108
21/64–24/64	5	86	10	143	21	118	36	116
25/64–28/64	1	161	4	145	5	86	10	131
29/64–32/64	0	0	0	0	1	76	1	76

pruning Worden grape vines, careful selection of canes as to their size is not necessary. The vigor of Worden grape vines as judged by the weight of wood removed in pruning is an index of the fruitfulness of the plants.

Literature Cited

1. Pickett, W. F. A preliminary study of the fruiting habit of the Worden grape. Proc. Am. Soc. Hort. Sci., 135. 1926.
2. Pickett, W. F. Further studies on the fruiting habit of the grape. Proc. Am. Soc. Hort. Sci., 151. 1927.

Pruning Studies with Beta Grapes*

By W. H. ALDERMAN and W. G. BRIERLEY, *University of Minnesota, St. Paul, Minnesota*

THE common hardy grape grown in Minnesota is Beta, one of the few cultivated varieties of *Vitis vulpina*. It is a vigorous and productive variety producing medium-sized berries borne in medium-sized clusters, normally two to a shoot. The customary pruning practice follows the standard four-cane, single-trunk Kniffin system with 40 to 50 buds held for fruiting.

A growing suspicion that a practice that had become standard in other sections for the larger fruited varieties of *Vitis labrusca* might not apply equally well to the smaller bunched Beta led to a preliminary pruning test of a small number of vines in 1928. Three plots were laid out. The first was pruned to the usual four arms measuring from 13 to 15 feet and carrying about 3½ buds per running foot. Plot 2 was pruned to six lateral arms, two being tied to the upper wire of the trellis on either side of the trunk and single canes attached to the lower wire. This increased the amount of fruiting wood by approximately 50 per cent. The vines in plot 3 were pruned to eight laterals, thereby increasing the amount of fruiting wood 100 per cent. The canes were tied double on both the upper and lower wires. Double trunks were used when necessary to secure the required amount of fruiting wood. As indicated in Table I, the amount of wood actually retained in 1928 in the six- and eight-cane plots was somewhat in excess of the theoretical amounts sought. It is to be noted that the increase in cane length was accompanied by a substantial increase in yield per vine.

TABLE I—YIELDS OF BETA GRAPES IN 1928 AND 1929

Number Canes	1928		1929	
	Cane Length in Feet	Vine Yield in Pounds	Cane Length in Feet	Vine Yield in Pounds
4	14	9.33	13.0±.18	9.75±.27
6	27	13.73	20.4±.25	13.39±.34
8	33.6	15.04	26.6±.47	14.57±.51

The experiment was repeated in 1929 on a larger scale with replicated plots permitting a more satisfactory analysis of the data. It will be noted from a study of Table I that in 1929 in the six-cane plots the bearing wood was actually increased by 57 per cent and in the eight-cane plots by 105 per cent over the amounts carried by the standard four-cane series. The yields were strikingly similar to those of the preliminary test. The gain in vine yield, however, does not keep pace with the increase in bearing wood. An increase of 57 per cent in bearing wood produced an increase of 37 per cent in crop yield, while increasing the wood 105 per cent increased the yield only 49 per cent. This falling off in rate of crop increase is to be expected and indicates that the production curve as related to

*Published with the approval of the Director as Paper No. 911 of the Journal Series of the Minnesota Agricultural Experiment Station.

amount of fruiting wood retained is rapidly flattening out and that approximately 25 feet of fruiting wood with 85 to 90 buds is probably about the maximum that should be retained for a Beta vine in average vigor.

TABLE II—EFFECT OF PRUNING UPON NUMBER AND SIZE OF CLUSTERS IN 1929

Number Canes	Cluster per Vine	Cluster Weight in Ounces	Per cent Loss in Cluster Weight
4	69.0±1.5	2.26±.04	0
6	99.3±0.9	2.16±.036	4.4
8	110.6±3.0	2.09±.048	7.5

An examination of Table II indicates the effect of increasing the amount of fruiting wood upon number of clusters per cane and the size of the individual cluster. As would be expected, the increase in yield is accounted for by the increase in number of clusters per vine made possible by the additional number of fruiting shoots which developed. The increase in number of clusters was relatively greater than the increase in weight of fruit. In the six-cane plots the gain in production was 37 per cent compared to a gain of 44 per cent in number of clusters. In the eight-cane plots the increases were 49 per cent and 62 per cent respectively. This reduction in size of clusters is relatively small when considered from the standpoint of the individual bunch, the reduction being 4.4 per cent for the six-cane plots and 7.5 per cent for the eight-cane plots. In the production of high grade table grapes, such a loss might be important, but in grapes used for juice and culinary purposes total yield assumes greater importance than size of cluster.

These experiments suggest the desirability of studying the proper pruning practice for other varieties of grapes in which the clusters normally are medium or below in size. The effects of these higher yields upon subsequent crops has not yet been studied and it is quite possible that a vine of average vigor might exhaust itself in one season to such an extent that the succeeding crop would be materially reduced. A great many of the vines in the vineyard where the 1929 tests were conducted suffered severely from a die-back of the new canes during October and early November. Although it was not possible to correlate this with possible over-production, it was noticeable that the most vigorous vines suffered least. The relationships between high yields and subsequent vine vigor, productiveness, and hardiness offer a promising field for further study.

The Training of Certain Grape Varieties to the 6-cane Kniffin System

By A. S. Colby, *University of Illinois, Urbana, Ill.*

DURING the past few years, numerous investigators have shown that the grape vine should be pruned according to its vigor and, therefore, its bearing capacity. Vigor is greatly influenced by variety, climate, and soil. Pruning is a thinning process, and not only influences the current season's crop but also determines the nature of the shoot growth which develops into the next year's canes. The correct number of fruiting buds should be left on the one-year-old canes so that the vigor of the vine will be balanced to correspond to its fruiting capacity.

Some recent work has shown the importance of size of cane in relation to productivity. In Michigan, Partridge (1924) found that canes from .25 to .30 inch in diameter as measured between the 5th and 6th nodes were the most productive. Studies in this State (Colby and Vogele, 1924) show that somewhat larger canes, up to .37 inch, could be used under Illinois conditions. Partridge also noted that canes ranging from 5 to 8 inches in internodal length between the 5th and 6th nodes proved the most fruitful. While internodal length was not so closely correlated with yield as was cane diameter, there was no great difference in their value. It was concluded that it would be better to use both measurements in the selection of fruiting canes rather than to rely on one alone.

The fruiting capacity of the bud also varies according to the position on the cane. This was first shown by Keffer (1906) in Tennessee. Shoots arising from the basal buds bear very little fruit. The more productive portion of the cane is farther out, from the 3d to at least the 13th node. Its exact position varies with seasonal and vine conditions. Similar results were secured in studies by Maney (1915) in Iowa, Schrader (1923) in Maryland, and Partridge (1925) in Michigan. These results are confirmed by unpublished data from this Station.

The location of the point of maximum production is evidently, at least in part, a response to conditions of growth the preceding season. This view is strengthened by the fact that the point of maximum production moved toward the base of the cane on vines in certain of the experimental blocks following a very large crop (Partridge 1925).

The 4-cane Kniffin system of training Concord is best under Illinois conditions (Colby 1925). This is usually the most economical method, all things considered, which will provide a good crop of quality fruit each season and at the same time result in the growth of sufficient fruiting wood, properly placed, for the next year.

There are, however, certain limitations to the use of this system where the soil is very fertile and the site is otherwise suitable for grape growing. This is especially true where the vines were planted from 7 to 10 feet apart, the latter distance being generally recognized as a maximum between vines in the older vineyards. More space is needed on the trellis than is available with this planting distance if

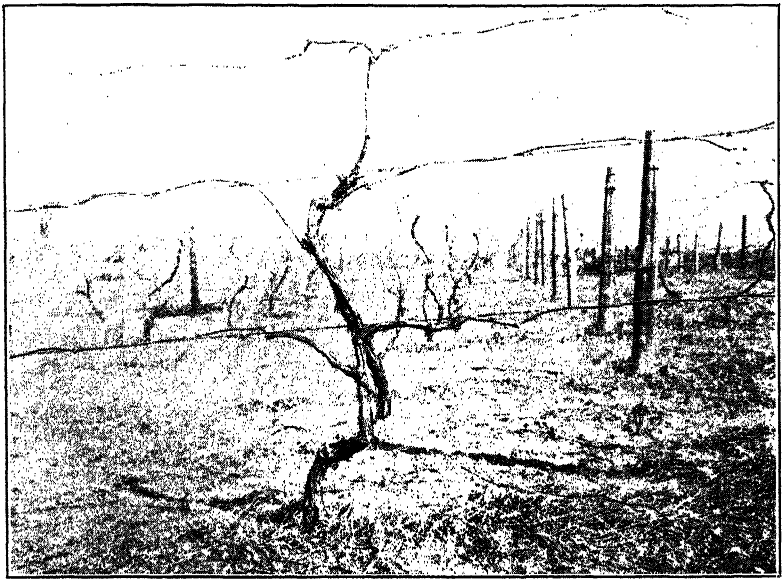


FIG. 1. Vine trained to the 6-cane Kniffin system.

FIG. 2. Same vine before pruning.

enough buds are to be left on only four canes to balance vigor and fruiting capacity of the vine from one year to another. Some modifications in the usual method of training may therefore be used to advantage.

In connection with the varietal testing work at the University of Illinois, a vineyard was planted in 1917 and 1918 on brown silt loam of morainal origin of rather high fertility. The site is well drained as regards both air and water. The planting distance was 10 x 10 feet and the vines were trained according to the 4-cane Kniffin system.

As the vines of certain vigorous varieties reached full bearing age it became evident at pruning time that the trellis space allotted to each plant was insufficient for the length of cane needed to balance individual vigor and fruiting capacity. Good fruiting wood sufficiently close in to the trunk was difficult to find. Suitable canes were available farther out on older wood, but if used they would be encroaching on the trellis space which belonged to the next vine. On the other hand, if fewer buds were left, excessive wood growth resulted, with a concurrent decrease in the crop.

Under these conditions it was thought that more fruiting wood might be made available to balance vine vigor and thus increase productivity, by training the vines to the 6-cane Kniffin system and pruning to leave more buds. Accordingly, in the winter of 1927 five vines each of several vigorous varieties (Table I) were trained as usual to the 4-cane Kniffin system while five more in the same row close by were trained to the 6-cane system (Figs. 1 and 2). From 45 to 55 buds were left on the vines trained to the usual system, with from 70 to 85 where six canes were used. The experiment was repeated with the same vines in 1928 and 1929.

The principles governing the choice of the most productive canes noted earlier in this paper were kept in mind at pruning time. No difficulty was experienced in changing from one method to the other. There was sufficient good wood available on the second wire to extend the trunk to a third and to carry two fruiting canes along the wire, one in each direction.

Considerable judgment was necessary in the choice of fruiting canes. There was a marked tendency for some of the varieties to produce the best renewal wood on the two upper wires. In such cases the number of buds left on the most promising canes was increased to correspond with their individual vigor.

There was some additional expense in adding a third wire to the trellis, since it had to be supported by "two by fours" nailed to the original posts. Strong winds may cause some injury where only a portion of the vineyard is changed over to the 6-cane system because of the exposed position of the upper arms. In a new planting, however, all three wires can be lowered a few inches on the posts without much danger that the lowest canes will be injured by frost or that the fruit will be mud spattered. Vines trained lower by this system will be more convenient to handle in the vineyard operations.

In Table I comparisons are shown of the yield in pounds of fruit from five vines each of several representative varieties during the years 1927, 1928, and 1929. The vines were eleven years old at

TABLE I—COMPARISON OF YIELD IN POUNDS PER VINE WITH THE 3-WIRE AND 2-WIRE KNIFFIN TRAINING SYSTEM; 1927–29 INC.

Variety	1927			1928			1929*		
	3 Wire	2 Wire	Increase Due to Extra Wire	3 Wire	2 Wire	Variation Due to Extra Wire	3 Wire	2 Wire	Variation Due to Extra Wire
Champion	10.4	4.5	5.9	11.3	13.2	—2.0	11.67	10.50	1.17
Herbert	21.8	16.5	5.3	11.6	7.1	7.1	1.38	1.56	—.18
Concord	15.3	12.1	3.2	19.2	11.8	7.4	5.30	1.95	3.35
Clinton	15.8	6.9	8.9	9.8	7.2	2.6	17.00	9.40	7.60
Bacchus	13.2	7.7	5.5	17.7	8.3	9.3	10.25	11.17	—.91
Average	15.3	9.5	5.8±.55	13.92	9.5	4.4±1.2	9.12	6.91	2.21±.92

*The drop in production was due to a severe hail storm in June '29, cutting off many leaves and fruits.

the time the experiment was begun. Where the 6-cane system was followed, production was increased during the first 2 years in all but one case, that of the Champion in 1928. This was due to the fact that some of the fruit was stolen, the vines of this variety being close to a roadway.

The crop was much reduced in 1929 by severe hail injury in early summer. Even under such unfavorable conditions there was some increase in yield where the 6-cane system was followed. Including the year 1929 there was an increase in production of marketable fruit by 48 per cent as a three-year average under the 6-cane system. This variation occurred seemingly without regard to parentage of the varieties, since Champion and Concord are listed as *Vitis labrusca*, Herbert as *V. labrusca* x *V. vinifera*, and Clinton and Bacchus as *V. vulpina* x *V. labrusca* crosses.

During the period under consideration it has been noted that the general appearance of the vines under the 6-cane system was superior to the check plants in uniformity of cane growth of the most fruitful type.

Discussion and Conclusions

It appears that the gain resulting from the use of the 6-cane system is due to the fact that more buds are left at pruning time, as previously noted, without encroaching on the space needed by other vines on the trellis. The bud number was increased to advantage, resulting in a more even balancing of fruiting capacity and vine growth. There was also less tendency to biennial bearing. Again, the most productive portion of the canes is sufficiently close in to the trunk that relatively few of the low-yielding basal buds are left in comparison to the whole number at pruning time. It is not necessary to leave extremely long fruiting canes in order to secure good yields.

Vigorous varieties, such as the Champion, Concord, Herbert, Clinton, and Bacchus, planted 10 x 10 feet averaged 48 per cent increase in production, during the three-year period 1927–9 inclusive, when trained to the 6-cane instead of the 4-cane Kniffin system.

This type of training seems to be a satisfactory method of developing the fruiting wood close to the trunk and at the same time maintaining the desired balance between vigor and fruiting. Training to the 6-cane Kniffin system would be advisable only with the more vigorous varieties growing on soils high in fertility.

Literature Cited

1. Colby, A. S., and A. C. Vogele. Notes on pruning and training Concord grapes in Illinois. Proc. Amer. Soc. Hort. Sci. 21:384. 1924.
2. Colby, A. S. Additional notes on pruning and training grapes. Proc. Amer. Soc. Hort. Sci. 22:415. 1925.
3. Keffer, C. A. The fruiting habit of the grape. Tenn. Agr. Exp. Sta. Bul. 77:35. 1906.
4. Maney, T. J. Grape pruning: The spur and long cane systems compared. Ia. Agr. Exp. Sta. Bul. 160:211. 1915.
5. Partridge, N. L. Further observations on the fruiting habit of the Concord grape. Proc. Amer. Soc. Hort. Sci. 19:180. 1922.
6. ———. The fruiting habits and pruning of the Concord grape. Mich. Agr. Exp. Sta. Tech. Bul. 69. 1925.
7. Schrader, A. L. Growth studies of the Concord grape. Proc. Amer. Soc. Hort. Sci. 20:116. 1923.

Cambial Activity in the Red Raspberry Cane in the Second Season*

By W. G. Brierley, *University of Minnesota, St. Paul, Minn.*

STUDIES of the performance of the fruiting cane of the red raspberry have been carried on at the Minnesota Experiment Station for several years. These studies, dealing primarily with the effects of height of pruning on yields, and with food substances in the cane as a whole, led to a consideration of the question of cambial activity in the cane during the second, or fruiting season. This phase of the general problem was studied in detail at the Michigan State College during the winter of 1928–29.

Apparently the behavior of the cambium in the raspberry cane in the second year has not been reported upon, but studies of cambial activity and radial growth in other plants have a bearing on the subject. Reiche (5) in 1897 noted that radial growth in trees did not occur unless bud development preceded it and showed the close relation between bud development and cambial activity in woody stems. Lutz (3) at the same time showed clearly that the initiation of new growth is from above downward. Hastings (2) found in broad-leaved deciduous species no cambial activity until the buds opened and the first new wood was formed in the neighborhood of the terminal buds. Grossenbacher (1) in his studies of annual rings showed that cambial activity begins in year-old shoots just back of unfolding buds and proceeds downward. Swarbrick (7) in his studies of cambial activity in the apple found xylem differentiation begins in the terminal region of all shoots and spurs and progresses downward toward the roots. In a later study Swarbrick (8) found no cambial activity in areas girdled above and below, and disbudded. McDaniels (4), studying fruit bud formation in the raspberry, found that no growth occurred when old canes were disbudded. The present studies show that the raspberry cane in the second season behaves in much the same way as other woody stems relative to cambial activity, but this activity in general is feeble.

In the red raspberry cane in the second season there is very little increase in radial thickness, but nearly all canes show some evidence of such growth. Measurements of dormant new canes made at 5-cm. intervals from the ground upward show when averaged a very regular decline in diameter regardless of cane length or vigor. Similar measurements of old canes after the fruiting season show a greater diameter from 5 to 50 cm. above the base than at the ground, the diameter at successively higher points then declining regularly toward the tips. This general difference in diameters indicates that radial growth occurs in the central and upper portions of the average cane, but not at the base. This condition is verified for 90 per cent of old canes by an examination of the internal structure.

From studies of the dormant year-old cane and of canes at the beginning of the second season it appears that the cambium is in the resting condition noted by Roberts (6) in apple seedlings. Apparently considerable stimulus from the growing laterals is necessary

*Published with the approval of the Director as Paper No. 910 of the Journal Series of the Minnesota Agricultural Experiment Station.

to cause the cambium to become active. In some cases the cambium does not seem to have become active at all. In others the cells have increased in radial diameter without dividing. Again, the outer cells of the cambium appear to have differentiated into phloem, but no new cambial cells and no new xylem elements were formed. In addition to behavior of these types, various instances of greater cambial activity have been noted up to the cases in which relatively large areas of new xylem have been found either in partial or complete rings.

The amount of new xylem formed varies with the vigor of the cane during the second year and does not appear to be related to vigor during the first year. The formation of new xylem begins just beneath the point of bud insertion and proceeds downward. This activity has not been found until the fruiting laterals have made a growth of two to three centimeters and have several welldeveloped leaves. In some instances laterals were found growing to a length of 20 cm. with the blossom buds well developed without appearing to stimulate cambial activity in the old cane. When the cambium does become active, it appears to form a relatively large amount of new xylem close to the point of shoot insertion, but this area rapidly diminishes until at only a centimeter or two below there is very little new xylem formed. The fruiting lateral is therefore not well attached to the old cane. This explains why the laterals break so easily from the old cane.

In the upper portion of the old cane there are usually enough laterals developed to stimulate the cambium into general although somewhat feeble activity and some increase in diameter results. This appears to occur even in the very tip of the cane where diameters are very small, providing vigorous laterals develop in that region. Field observations have shown that in general there are few vigorous laterals near the base of the average old cane. As the stimulus from the laterals does not seem to cause the cambium to become active at any great distance below the points of insertion, the cambium near the base of the average cane remains in the resting condition. In this condition there is no new xylem formed and the cane does not increase in diameter in this region. When vigorous laterals are produced close to the ground, xylem formation generally does take place in the basal region of the cane and increase in diameter results. This condition has been found in approximately 10 per cent of the old canes studied.

Though evidence relating to phloem formation is not as extensive, darker staining of the inner portion of the phloem indicated that in some cases new phloem may have been formed when the cambium became active. At the base of canes where no new xylem was produced no indication was found that new phloem was formed. Although in some instances new phloem was found without new xylem differentiation, this behavior was in the central or tip regions of the cane and not at the base.

Degeneration of the phloem at the base of the old cane possibly may cause the death of the old cane or contribute to that result. In plants grown in the greenhouse, browning of the phloem at the base of the cane was noted, beginning about the height of the fruiting season. In the field no discoloration of the phloem at the base was

found until the canes had about finished fruiting and at that time the specimens examined showed only a light browning. After the death of the old canes the phloem at the base usually was dark brown and the cells in some cases were collapsed. At the same time the phloem in the central region of the cane was in apparently normal condition with the cell contents seemingly intact and with no discoloration evident. In the tip region of the old canes browning of the phloem occurs at about the same time as in the basal region, or may occur earlier. This is judged to be due to a failure of the water supply resulting in the drying up of this region.

In another phase of these raspberry studies chemical analyses have shown a considerable residue of reducing sugars in the old cane and laterals. It is considered possible that either a decline in phloem activity or a breakdown at the base will explain the presence of this residue. From such evidence it appears probable that there is little transport of elaborated foods to the root from the old cane after the harvest season, and that removal of the old cane at this time results in little or no loss of food supply to the roots.

In relation to these studies of the red raspberry cane some limited studies of two-year-old canes of the Evergreen blackberry are worthy of mention. In the late fall these old canes, obtained from the Western Washington Station at Puyallup, showed at the base an extensive area of phloem apparently for the most part in good condition. Although no second-year xylem was found in this region of the cane, it seems very possible that the formation of phloem in the second year or the persistence in active condition of the old phloem may explain why these canes continue to live and often bear fruit in the third season under favorable climatic conditions.

Though the decline of the phloem may be one explanation for the death of the old raspberry cane, it should be noted that in the course of these studies some evidence of tylose formation was found in the old canes. This indicates that water transport may be disturbed some time in the second season. This disturbance may have an effect equal to or greater than phloem breakdown in relation to the death of the old cane.

Literature Cited

1. Grossenbacher, J. G. The periodicity and distribution of radial growth in trees and their relation to the development of "annual" rings. Trans. Wis. Acad. Sci. 18. Pt. I:1. 1915.
2. Hastings, G. T. When increase in thickness begins in our trees. Plant World 3:113. 1900.
3. Lutz, K. G. Beitrage zur Physiologie der Holzgewächse. Beitrage Wiss. 1, 1. 1897.
4. McDaniels, L. H. Fruit bud formation in *Rubus* and *Ribes*. Proc. Am. Soc. Hort. Sci. 194. 1922.
5. Reiche, K. Zur Kentniss der Lebensthätigkeit einiger shilenischen Holzgewächse. Jahrb. Wiss. Bot. 30: 81. 1897.
6. Roberts, R. H. Factors affecting the variable growth of apple grafts in the nursery row. Wis. Agr. Exp. Sta. Res. Bul. 17. 1927.
7. Swarbrick, T. Studies in the physiology of fruit trees. I. The seasonal starch content and cambial activity in one- to five-year-old apple branches Jour. Pomol. and Hort. Sci. VI:2:137. 1927.
8. ———. Studies in the physiology of fruit trees. II. The effects of ringing, double ringing, and disbudding upon the starch content and cambial activity of two-year-old apple shoots. Jour. Pomol. and Hort. Sci. VI: 4: 296. 1928.

Runner Plant Formation in the Dunlap Strawberry

By H. W. Richey and J. C. Schilletter, *Iowa State College, Ames, Ia.*

SINCE most of our commercial strawberry plantings are grown by the matted row system of culture the horticulturist is interested in the development and production of runner plants. Casual observation will show that different varieties vary widely in their ability to form runners and that there is a noticeable variation in the same variety when grown under different, soil, cultural, and climatic conditions. A more intimate knowledge of runner formation and the growth and productivity of the different individual plants on the various runner series may be of service in determining the time of planting, the distance of planting, and the amount and kind of thinning.

In this particular study it was desired to determine, (1) the average number of days after planting until the formation of the first plant on each runner series from a mother plant; (2) the average number of plants formed on the various runner series; (3) any possible relationship between the time of starting of a runner series and the number or rate of plants formed on the series; (4) the average number of days intervening between the formation of the successive runner plants on the runner series; (5) any association of rate of plant formation with any noticeable condition of temperature or moisture; (6) the period of most rapid plant formation.

In the studies of strawberry plant growth made at the Iowa State College, the mother plants are allowed to develop only the first five runner series that form. All others are pinched off as soon as noticed. In this study each runner series was confined to an unbranched line of runner plants as all secondary runner series that arose either from the first nodes of the runner or from the successive plants on the primary runner series were removed as soon as observed. The plants were examined every two or three days and the undesired plants removed. Any newly formed plants that were to be kept for the prolongation of the primary runner series were fastened to the ground and a record made of the date of plant formation. Runner plants were considered to have formed when the first white root knobs were evident on the elbow of the turned up end of the runner which develops into the new plant.

Dunlap strawberry plants were carefully selected for apparent uniformity of vigor and size and properly planted in a good fertile garden loam. The plants were set under irrigation so that water could be added in case it was deemed advisable in order to prevent dry weather from causing a retardation of runner formation. Light applications of water were given at six periods during 1927 and two light applications were made to the 1928 planting. At no time was the lack of water a serious feature but it is possible that the drier periods may have had some influence although irrigation water was applied when general conditions indicated that such an application was advisable.

In 1927 the mother plants were set April 29th. They were planted 28 inches apart in rows 4 feet apart. These plants were thinned as conditions necessitated and any plants not making uniform growth comparable with the others were discarded from the experiment. The plants used for the study in 1928 were treated in a similar fashion to those of 1927 except that they were planted April 25 and were set 4 feet apart in rows 5 feet apart. This wide spacing was used in order to facilitate the training and staking of the plant. Although the plants grew fairly well in the summer of 1927 the climatic conditions were not nearly as satisfactory for plant growth as they were in 1928, and in the latter year the plants developed much better.

In 1927 the 83 mother plants, each with its five runner series, produced 2515 runner plants during the 19 weeks of the experiment. In 1928 the 73 mother plants, trained similar to those of the preceding year, produced a total of 2920 runner plants during 21 weeks.

TABLE I—AVERAGE NUMBER OF DAYS FOR THE FORMATION OF THE FIVE RUNNER SERIES FROM THE MOTHER PLANTS.

Year	Number Mother Plants	Av. Number Days for Formation of Runner Series						Range in Days
		1	2	3	4	5	Av.	
1927	83	61	68	75	83	91	76	30
1928	74	56	60	63	66	69	63	13

Table I shows the average number of days intervening from the time of setting the mother plants to the time of rooting of the first plant on each of the runner series. It will be noted that runner plant formation started more quickly after planting in 1928 than in 1927, and that the difference in time for the formation of the first runner plant on the five series became progressively greater from the first to the fifth series in 1927. Even after careful selection of plants for their apparent similarity there was an average interval of 30 days between the formation of the first plant on the first runner series and the formation of the first plant on the fifth runner series in 1927. A period of but 13 days was required for similar growth in 1928. An average of 76 days was required for the initiation of the first plant on all five runner series in 1927 and an average of 63 days was required in 1928.

TABLE II—AVERAGE NUMBER OF PLANTS FORMED ON THE DIFFERENT RUNNER SERIES.

Year	Number Mother Plants	Runner Series					
		1	2	3	4	5	Av.
1927	83	7	7	6	6	5	6
1928	74	8	8	8	8	8	8

Table II shows that the average number of plants per runner series in 1927 ranged from 7 to 5 with an average of 6 for the five series. In 1928 all five runner series produced an average of 8 runner plants. An examination of Table III shows that in 1927, only 49 of the 83 mother plants produced runner series that had as many as 8 plants per

TABLE III—AVERAGE NUMBER OF DAYS INTERVENING BETWEEN THE FORMATION OF SUCCESSIVE PLANTS ON A RUNNER.

Year 1927				Year 1928		
Number Days Intervening	Number Mother Plants Producing Such Runners	Total Number Runner Plants in Such Position	Numerical Position of Plant on the Runner	Total Number Runner Plants in Such Position	Number Runner Plants Producing Such Runners	Number Days Intervening
76	83	415	1	370	74	63
11	83	415	2	369	74	11
13	83	410	3	368	74	10
15	83	394	4	366	74	11
14	83	344	5	362	74	12
14	79	269	6	342	73	12
15	68	171	7	302	73	13
15	49	83	8	233	65	16
15	12	13	9	141	58	18
14	1	1	10	54	32	18
			11	12	11	12
			12	1	1	16
		2515		2920		

series and there were but 83 runner plants occupying the 8-position on a runner series. In 1928, 65 of the 74 mother plants produced runner series with eight plants each and a total of 233 plants in that position. The average production of runner plants per runner series was greater in 1928 than it was in 1927 and in 1928 a larger percentage of mother plants produced more runner series with more plants per series than was the case in 1927. In those cases where there was much difference in the time of initiation of the runner series those series that were in the first to form produced the most runner plants.

Table III indicates that there was considerable uniformity in the length of time intervening between the formation of successive plants on the same runner series. With the exception of the latter part of the season these intervals were shorter in 1928 than they were in 1927. After the formation of new plants had gotten well started, additional plants seemed to form at about the same rate apparently irrespective of the age of the runner series or of the position of the new plant on the runner. This rate of growth, however, did seem to be influenced somewhat by climatic conditions.

In 1927 the average temperature was several degrees lower, for the first six weeks after planting, than it was for the similar period in 1928. On the basis of weekly averages there was only one time during this period in 1927 that the average mean temperature got as high as it did during the corresponding period of 1928. The precipitation was greater at time of planting in 1927 than it was in 1928 but in 1928 a light irrigation was given immediately after planting. A noticeable dry period of about 10 days preceded the beginning of runner formation in 1927. A light irrigation was given which was soon followed by a rain. Then with a 10 degree rise in average mean temperature, runner plant formation started very rapidly. The rapidity of early growth was more pronounced in 1927 than in 1928 when the temperature and moisture were more uniform. Although the initial growth started out more slowly in 1928 an increase in precipitation accompanied by an increase in temperature was associated with a very marked increase in the formation of plants.

There was considerable irregularity in the rate of plant formation in the latter part of 1928. Graphs plotted from temperature, precipitation, and plant growth data indicated that some of the earlier irregularity of this period probably would have been smoothed out with a larger number of plants but that the later irregularities conformed quite closely to changes in moisture and especially temperature. It is true that the plants were irrigated, but apparently irrigation water should have been applied a few days earlier although the plants gave no apparent appearance of water deficiency. Only two applications were given in 1928 and both of them were followed by rain within 24 hours. Frequent light applications were made in 1927 so that it is probable that the moisture content of the soil was more constant during the period of most rapid plant formation in 1927 than it was in 1928.

On the basis of percentage the growth of the plants conformed quite closely to the standard growth curve. Slow initial formation of new plants was followed by a rather rapid increase which was

maintained for a considerable period but was, in turn, followed by a rapid decline which soon became more gradual. The rapid changes seemed to accompany pronounced changes in moisture and especially temperature. The formation of new plants was noticeably decreased when the average mean temperature was 55 degrees F. or lower.

The data showed that the period of most abundant plant formation during the two years took place from July 8 to August 26. In both of these years there was a pronounced decline in plant production in the last few days in July or the first few in August, which period would have marked the peak of runner formation in contiuning the growth on the standard growth curve.

Quality of Texas Lower Rio Grande Valley Grapefruit[1]

By H. P. Traub, G. S. Fraps, and W. H. Friend,[2]
College Station, Tex.

THE rise of the citrus industry in Texas is one of the outstanding horticultural developments of the present decade. From an output of 15 cars in 1921, the industry has expanded to an estimated production of over 4,000 cars in 1929–30. The total citrus trees planted in the Lower Rio Grande Valley up to July 1, 1929, numbered 5,118,981; of these 72 per cent were grapefruit; and 13 per cent of these latter were 5 years of age or older (17).

The chief commercial production is centered in the Lower Rio Grande Valley, but the industry is being extended to the Laredo District, and the Winter Garden Region of Texas. The superior quality of Texas grown grapefruit[3] has received recognition, but the factors responsible for this are imperfectly understood. Precise information regarding this subject is of immediate value in any consideration of legal standards for grapefruit in Texas, and will also meet urgent requests for information regarding the factors affecting grapefruit quality from growers, marketing organizations, and buyers of the Texas product.

The Florida and California standards are based upon extensive data (2, 3, 12). The California law requires a minimum of 6 parts of total soluble solids to 1 of anhydrous citric acid (determined by titration) for District No. 1, and 5½ to 1 for District No. 2; except that after June 1 until the crop is sold, all fruit is considered mature irrespective of the analysis of the juice. The Florida law sets up a decreasing minimum ratio of solids to acids with increasing total soluble acids of the juice:

Per cent Total Soluble Solids*.....	8.5	9.0	10.0	11.0	12.0
Minimum Ratio;* Solids/Acids...	7–1	6.5–1	6–1	5.5–1	5.0–1

*Tolerance factor = 0.2

The Texas law requires a minimum total soluble solids content of 10 per cent and a ratio of 7 to 1 of acids, except for early seeded varieties, after Oct. 15, for which the requirements are the same as those set up in the table for Florida beginning with the second column with 9 per cent total soluble solids and a ratio of 6.5 to 1. It is apparent that the Texas standard is the most exacting, and should be reviewed in the light of reliable scientific experiments in order to prevent any unjustified hardships to growers.

---

[1]Published with the approval of the Director as Contribution No. 90 of the Technical Series of the Texas Agricultural Experiment Station. (Scientific Paper No. 46, Division of Horticulture.)

[2]Thanks are due Miss Emerald Isbell, and Messrs. C. M. Burroughs, and R. C. Griffing for competent assistance in the laboratories.

[3]The Pomelo or Grapefruit, (*Citrus paradisi*, Macf.; paradisi, of paradise, or gardens; also known as *C. maxima* var. *uvacarpa*) is here considered as a species distinct from the Pummelo or Shaddock, (*Citrus maxima*, Merrill; known also as *C. grandis*, and *C. decumana*) See Swingle (14; 15).

The plan of the experiment includes a study of Texas grown grapefruit in terms of physical and chemical constants thru the developing and mature stages in an attempt to place an estimate of quality on a sound scientific basis.

Materials and Methods

The varieties included in the study are those chiefly planted commercially in Texas, namely, the yellow-fleshed varieties, Marsh (syn. Marsh Seedless), and Duncan (7), and the pink-fleshed mutations, (8, 11, 13) Thompson (syn, Pink Marsh), and Foster (syn. Pink Walters).

The fruits used for analysis were grown at Texas Substation No. 15, near Weslaco in the Lower Rio Grande Valley. From 36 to 48 hours usually elapsed between harvesting and analysis. On arrival at the laboratory, samples were stored at 40 to 45 degrees.F. The juice was expressed by means of an ordinary glass grapefruit juice extractor; and was strained thru cheesecloth.

The methods of the Association of Official Agricultural Chemists (1), were used for most of the macrochemical determinations.[4] Dry matter was determined on 10 grams dried in a vacuum at 70 degrees C; total solids by the use of the Brix hydrometer, correcting for temperature; sugars by the Munson and Walker Method; acids by titration with standard hydroxide at room temperature, using phenolphthalein as indicator and expressed as anhydrous citric acid; protein, total ash, insoluble ash, phosphoric acid, potash, lime and magnesia as described in a former paper (16).

The pH and basic values for the buffer indices were determined on a Leeds and Northrup hydrogen ion apparatus to three decimal places. The buffer capacity of grapefruit juice has been expressed quantitatively as the Van Slyke (18) buffer index, which is defined as the differential quotient of the increasing amount of the base, expressed in equivalents per liter, over the corresponding change in pH. A solution, therefore, has a buffer capacity of 1.0 when a liter of it alters its reaction one pH unit upon the addition of one equivalent of acid or base. Citric acid was used in these determinations.

The apparent nature of the red pigment in Thompson and Foster grapefruit was determined by the usual technic (8, 9).

In addition to the above analyses, the following quantitative measurements were made, namely, weight of entire fruit, juice, "rag," rind; width of rind and diameter of pulp in mm.; number of locules, number and weight of seeds.

Samples consisted of 10–15 or more fruits. Denny (4) has reported on formulae for the determination of the number of fruits required for adequate sample for analysis (6). In the present case, errors due to methods of analysis (19, 10) are apparently small as compared with the variability of the individual fruits with respect to the constituents determined. Since no attempt will be made in these preliminary analyses to compare the results with those from other

[4]Thanks are due Dr. E. M. Chace, of the U. S. D. A. for encouragement and valuable suggestions.

regions, the number of fruits utilized per sample was considered adequate. The trends indicated in the present report (Nov. 1928 to Dec. 1929) should be checked up on a greater number of samples over several seasons to complete the work. All of the data here presented will be considerably amplified in succeeding seasons.

Developing Fruit

During the season of 1929, from Apr. 27 to Oct. 5, the Marsh grapefruit studied reached a maximum weight of approximately 466±7 grams, between late Sept. and early Oct. as shown in Table I; the ratio of length to width, approximately 1 to 1, remained practically constant during the entire season indicating that the fruit is round for practical purposes; the percentage of juice increased from 40 per cent in late Aug. to 50 per cent in late Sept.

TABLE I—Development of Marsh Grapefruit; Apr. 27 to Oct. 3, 1929, Weslaco, Texas.

Date	Mean (10 Individuals)				
	Weight, gms.	Diam., cm.	Length, cm.	Ratio: Diam. Length	Per cent of Juice
Apr. 27	35.7	4.4	4.5	0.97	
May 4	53.5	5.2	5.1	1.01	
May 11	65.7	5.5	5.7	0.96	
May 18	81.6	6.1	6.0	1.01	
May 25	94.4	6.3	6.3	1.00	
June 1	118.9	7.0	6.8	1.02	
June 8	135.1	7.1	7.0	1.01	
June 15	171.9	7.7	7.7	1.00	
June 22	178.1	7.8	7.6	1.02	
June 29	185.0	7.8	7.6	1.02	
July 6	212.9	8.1	7.9	1.02	
July 20	232.4	8.3	7.8	1.06	
July 27	237.5	8.3	7.8	1.06	
Aug. 3	238.9	8.4	7.8	1.07	
Aug. 10	336.6	9.7	8.4	1.15	
Aug. 17	342.1	9.6	8.8	1.09	
Aug. 24	348.6	9.7	8.7	1.10	43.1
Aug. 31	358.5				46.6
Sept. 7	377.3	10.0	8.5	1.17	51.8
Sept. 14	444.8	10.3	9.4	1.09	52.8
Sept. 21	461.2	10.8	9.3	1.16	52.1
Sept. 28	466.4	10.6	9.7	1.09	
Oct. 5	466.6	10.5	9.6	1.09	
Oct.5–Dec.3 (32 individuals)	466.2 ±7.6				54.7

Composition of Juice. From late August to the middle of October the total solids of the juice changed only slightly, if at all (Table II); sugars exhibit little variation; acids, by titration, decrease slightly (Fig. 2a); total change in protein and ash fractions is slight (Table II).

Apparently as early as late August the juice of grapefruit grown under Texas conditions reaches a relatively stable condition. Altho definite changes in absolute values may take place, such changes are

TABLE II—COMPOSITION OF MARSH GRAPEFRUIT JUICE, 1928–1929, WESLACO, TEXAS.

Date	Total Solids	Carbohydrates			Protein N x 6.25	Ash Fractions					
		Reducing Sugars	Non-reducing Sugars	Total Sugars		Total Ash	Insoluble Ash	Lime	Magnesia	Phos. Acid	Potash
					I. Per cent Fresh Weight						
1929											
Aug. 24	11.00	4.08	3.47	7.55	0.54	0.38	0.013	0.003	0.009	0.036	0.23
Aug. 31	11.00	3.73	3.72	7.45	0.49	0.39	0.0138	0.0135	0.0153	0.036	0.22
Sept. 7	10.50	3.75	3.45	7.20	0.60	0.31	0.013	0.006	0.010	0.035	0.25
Sept. 14	10.40	3.54	3.35	6.89	0.53	0.29		0.008	0.002	0.035	0.23
Sept. 21	11.00	3.56	3.21	6.77	0.59	0.28		0.017	0.012	0.035	0.22
Oct. 19	10.20	3.07	3.66	6.73	0.60		0.011	0.015		0.045	0.22
1928											
Nov. 19 to Dec. 17											
$\bar{X}$	9.42±0.17			6.68	0.59	0.33	0.039	0.014	0.0151	0.035	0.19
				±0.10	±0.002	±0.001	±0.0004	±0.000008	±0.000006	±0.000006	±0.001
S. D.	0.64±0.12			0.37	0.008	0.005	0.0017	0.00003	0.00002	0.00002	0.004
				±0.07	±0.001	±0.001	±0.0003	±0.000005	±0.000001	±0.000001	±0.0007
C. V.	6.79			5.53	1.40	1.63	4.35	0.21	0.13	0.06	2.15
					II. Per cent Dry Weight						
1929											
Aug. 24		37.09	31.54	68.63	4.90	3.45	0.118	0.027	0.081	0.327	2.09
Aug. 31		33.90	33.81	67.73	4.45	3.54	0.125	0.122	0.139	0.327	2.00
Sept. 7		35.71	32.85	68.57	5.71	2.95	0.123	0.057	0.095	0.333	2.38
Sept. 14		34.03	32.21	66.25	5.09	2.78		0.076	0.019	0.336	2.21
Sept. 21		32.36	29.18	61.54	5.36	2.54		0.154	0.109	0.318	2.00
Oct. 19		30.09	35.88	65.98	5.88		0.107	0.147		0.441	2.15

TABLE III—COMPARISON OF FOUR GRAPEFRUIT VARIETIES; WESLACO, TEXAS, 1929.

Character	Marsh Oct. 5 to Dec. 3			Thompson Nov. 19 to Dec. 3			Foster Nov. 26 to Dec. 3			Duncan Sept. 30 to Oct. 14		
	$\bar{X}$*	S. D.	C. V.	$\bar{X}$**	S. D.	C. V.	$\bar{X}$†	S. D.	C. V.	$\bar{X}$‡	S. D.	C. V.
I. Whole Fruit												
Total weight, gms.	466.2±7.6	64.2±5.4	13.7	449.3±8.89	47.47±6.29	10.56	521.1±6.30	24.68±4.45	4.73	468.5±8.19	45.36±5.79	9.68
Weight of juice, gms	255.3±3.8	32.30±2.7	12.6	264.8±4.92	26.27±3.48	9.91	296.7±4.30	16.80±3.02	5.66	241.5±4.88	27.08±3.45	11.21
Per cent of juice...	54.7			58.9			56.9			51.5		
Weight of "rag," gms...........	96.1±3.23	27.06±3.28	28.13	83.6±3.2	17.31±2.2	20.68	96.7±1.47	5.76±1.06	5.95	105.8±3.76	20.85±2.65	19.69
Weight of rind, gms	110.6±2.89	24.27±2.04	21.94	98.7±3.05	16.32±2.1	16.52	109.6±2.86	11.23±2.02	10.24	107.0±3.15	17.50±2.20	16.35
Number of seeds..	3.9±0.30	2.54±0.21	64.14	6.5±0.46	2.48±0.32	37.97	54.7±0.68	2.69±0.48	4.91	63.0±1.64	9.14±1.16	14.50
Weight of seeds gms...........	1.3±0.08	0.75±0.06	57.20	2.1±0.15	0.81±0.10	38.57	17.8±0.36	1.41±0.25	7.89	21.8±0.72	4.00±0.51	18.33
Thickness of rind, mm...........	6.0±0.15	1.30±0.10	21.34	5.4±0.14	0.75±0.09	13.73	5.1±0.25	1.00±0.18	19.60	6.2±0.20	1.14±0.14	18.15
Diameter of pulp, mm...........	90.4±0.54	4.60±0.41	5.08	90.3±0.82	4.41±0.58	4.87	93.7±0.58	2.30±0.41	2.45	88.0±0.54	3.00±0.38	3.39
Number of locules.	13.3±0.15	1.26±0.10	9.46	13.7±0.29	1.55±0.20	11.26	13.2±0.24	0.96±0.17	7.22	13.2±0.22	1.22±0.15	9.18
II. Juice												
Total solids, per cent...........	10.3±0.19	0.70±0.01	6.75	9.43±0.015	0.38±0.10	4.10	10.48±0.46	0.98±0.33	9.36	9.47±0.13	0.34±0.09	3.59
Total sugars, +per cent...........	6.68±0.10	0.37±0.07	5.53									
Acids (by titration) per cent.......	1.14±0.01	0.14±0.01	12.28	1.09±0.01	0.10±0.01	9.17	1.18±0.02	0.10±0.01	8.47	1.09±0.03	0.17±0.02	15.59
Ratio: solids/acids......	9.0			8.65			8.88			8.68		
pH.............	3.18±0.02	0.20±0.01	6.25	3.27±0.04	0.14±0.01	4.28	3.29±0.06	0.24±0.046	7.29	3.30±0.03	0.17±0.025	5.15
Buffer capacity....	1.03±0.03	0.13±0.02	1.3	0.943 ±0.001	0.003 ±0.0008	0.32	0.956 ±0.002	0.003 ±0.001	0.32			

*Based upon 32 individuals.
**Based upon 14 individuals.
†Based upon 7 individuals.
‡Based upon 14 individuals.
+Data, Nov. 19 to Dec. 17, 1928; 60 individuals.

slight. Chace and Church (2) report similar results for California and Arizona.[5]

Quality of Texas Grown Marsh

Normally, the marketing of grapefruit begins about the middle of October. To determine the factors that might affect palatability,

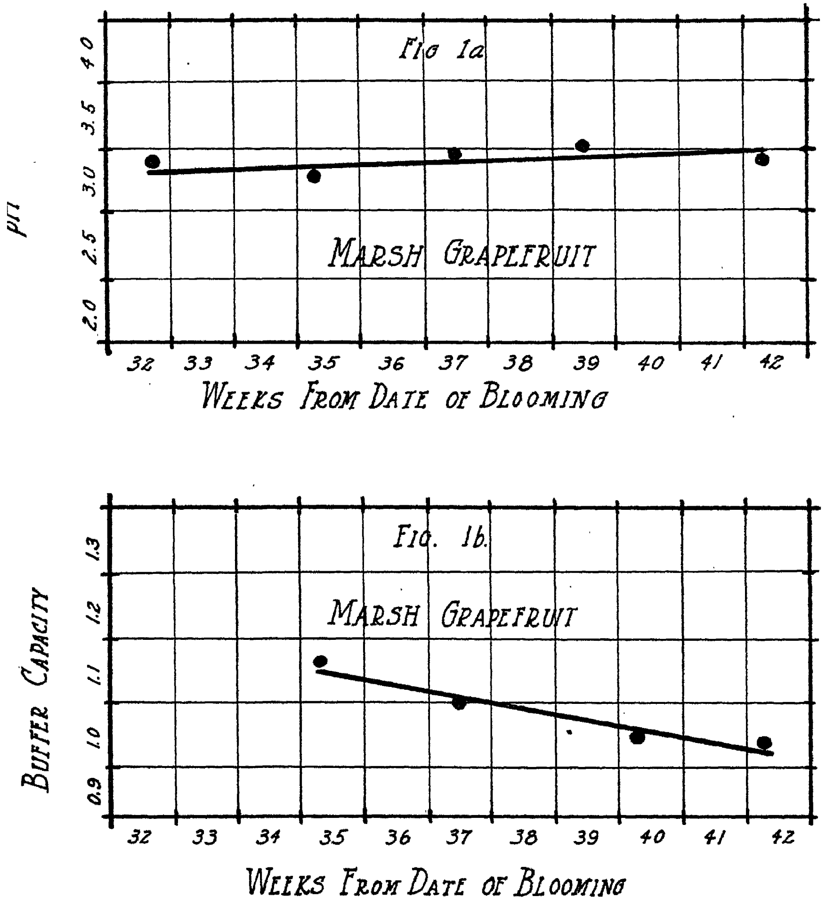


Fig. 1. Regression of pH (1a) and buffer capacity (1b) of juice on age of fruit.

an intensive study was made of the juice of this variety, from Nov. 19 to Dec. 17 in 1928, and Aug. 24 to Dec. 17 in 1929.

Preliminary inspection of the data indicated that within the period, Aug. 24 to Dec. 17, there is a correlation between the in-

[5]See Dominquez (5) for Porto Rico data.

creasing age of the fruit and changes in certain physical and chemical characteristics of the juice,—pH, buffer capacity, total solids, acids (by titration), and the solids/acids, ratio, as shown in Table IV. This relationship makes it possible to interpret the changes mathematically in the form of straight regression lines showing mean values as associated with increments of age. These facts are presented in Figs. 1 and 2.

pH and Buffer Capacity. Table IV, and the regression lines in Fig. 1 show that the pH value increases whereas the buffer capacity decreases with age. An increase in pH of less than 0.02 and a decrease in buffer index of approximately 0.05, is associated with each weekly increment of age. Apparently, these facts can not be used to explain any change in palatability since the total change in the pH of the buffered solution is comparatively slight.

TABLE IV—CORRELATION BETWEEN CHARACTER OF JUICE AND AGE OF FRUIT, NOV. 19 TO DEC. 17, 1928; AND AUG. 24 TO DEC. 3, 1929.

Character	Correlation of Character With Age in Weeks	Character	Correlation of Character With Age in Weeks
pH	0.36±0.11	Total solids	—0.48±0.11
Buffer capacity	—0.76±0.11	Acids (by titration)	—0.70±0.05
		Ratio: Solids Acids	0.58±0.06

Ratio: Solids/Acids;(by titration). The regression lines in Fig. 2, show that the total soluble solids of the juice decrease approximately 0.05 per cent with each weekly increment of age, but the relative decline of acids (by titration), less than 0.02 weekly, causes a weekly rise of approximately 0.1 in the ratio of solids to acids.

Palatability of Juice. Palatability in grapefruit juice has been characterized as "very sour," "sour" and "tart" by Collison (3). The juice of the Marsh fruit analyzed between August 24 and December 17 was characterized as "tart." To date no fruits analyzed between these dates yielded juice which could be classified as "sour" to the taste.

Theory of Taste. The preliminary work here reported indicates the urgent necessity of a fundamental theory which explains the factors affecting taste in citrus fruits as a basis for further progress in this type of investigation. Data are being accumulated on which it is hoped to base a comprehensive theory of the factors affecting taste in citrus fruits; these will be furnished at a later date.

Color of Flesh. Since the introduction of the pink-fleshed varieties, Thompson (11) and Foster (7), this character has attracted attention, and its practical value is a controversial subject at present. Table IV shows that the red coloring matter is apparently a carotinoid pigment (9) since it is insoluble in water, alcohol, etc., the ordinary solvents for anthocyanins (8), but it is soluble in the ordinary fat solvents, xylol, diethyl ether and chloroform. The complete experiment will be published elsewhere.

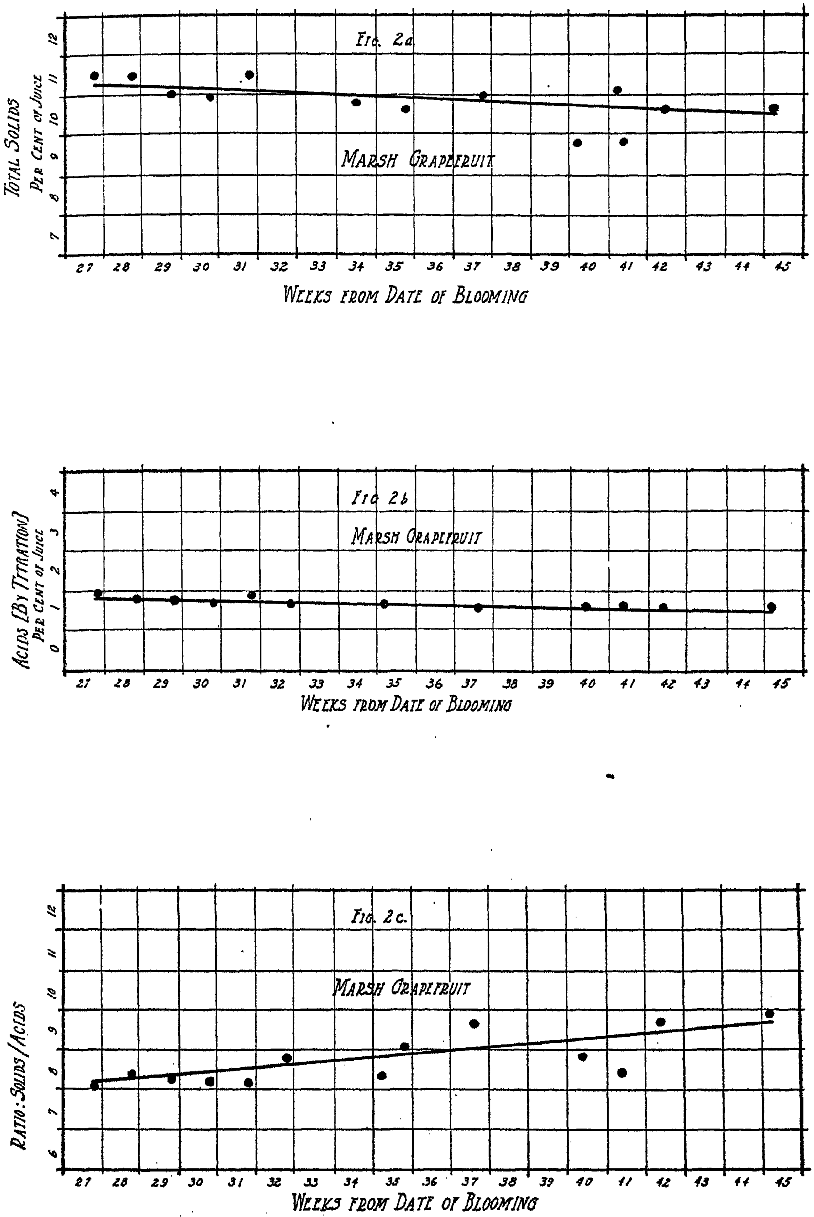


FIG. 2. Regression of total solids (2a); acids by titration (2b); and ratio: solids/acids (2c) of juice on age of fruit.

TABLE V—SOLUBILITY OF RED PIGMENT IN GRAPEFRUIT; TISSUE IN FRESH CONDITION.

Solvent	Thompson (Pink-fleshed)		Check: Marsh (Yellow-fleshed)	
	Solubility	Tissue Changes	Solubility	Tissue Changes
Chloroform	markedly soluble (solution pink)	changes to orange	filtrate clear	remains light yellow
Ethyl ether	v. slightly soluble (filtrate slightly pink)	turns to orange-yellow	do	do
Hot water	not soluble (filtrate light yellow)	remains pink	filtrate light yellow	do
Alcohol absolute cool	not soluble (filtrate light yellow)	do	filtrate light yellow	do
hot	do	do	do	do
95% cool	do	do	do	do
hot	do	do	do	do
50% cool	do	do	do	do
hot	do	do	do	do
75% Xylol	markedly soluble (filtrate pinkish orange)	changes to orange	filtrate clear	do
5% NaOH	not soluble (filtrate yellow)	remains pink	filtrate yellow	yellow
5% HCl	not soluble (filtrate light yellow)	do	do	remains light yellow

FOUR GRAPEFRUIT VARIETIES

The major part of the data presented concern the Marsh variety. However, it seemed advisable to include some data on other representative varieties in order to determine the relative constancy of characteristics in the species *Citrus paradisi*. These data are shown in Table III.

The mean weight of mature Marsh, Thompson and Duncan are practically the same, about 460±7 grams, on the basis of the limited number of individuals included. The higher mean weight for Foster will probably be changed on the basis of more measurements. The per cent of juice is practically constant for all varieties, somewhat better than 50. Measurements for amount of "rag" and rind are somwehat more variable than others. The outstanding difference in varieties on the basis of gross characters is in the number and weight of seeds. The magnitude of the C. V. is relatively high in seedy varieties such as Duncan. The number of seeds in Marsh, for instance, may vary from 0 to 6, thus giving rise to a relatively greater C. V. Thompson is similar to Marsh; Foster to Duncan.

The total solids/acids ratio is similar in all varieties studied, 8.5 to 9. pH varies but slightly,[6] 3.1 to 3.3. The buffer index is approximately the same for all four varieties. Number of locules is fairly constant for all varieties. Diameter of pulp varies only slightly, 88 to 93 mm; thickness of rind, 5 to 6 mm.

Conclusions

The preliminary results on quality of four varieties of Texas grown grapefruit, covering the period, late August to the middle of December, may now be summarized,—

1. Grapefruit juice, a buffered biological solution, has a pH range from 3.1 to 3.3; the total soluble solids decrease slightly with age, but the acids (by titration) decrease relatively more, causing a gradual rise in the ratio of solids to acids as the season advances;
2. The slight changes which occur in the constituents of the juice are not sufficient to cause changes in palatability;
3. All samples analyzed contained juice which was "tart" to the taste; no "sour" or "very sour" juice was encountered;
4. The ratio of solids to acids is always greater than 7.0 and rises gradually to more than 9.0;
5. The pigment responsible for the color in the pink-fleshed varieties of grapefruit is apparently a carotinoid;
6. On the basis of the characters studied, the four varieties; Marsh, Thompson, Foster and Duncan differ chiefly in the number and weight of seeds;
7. The preliminary results point to the necessity of developing a comprehensive theory of the factors affecting taste in citrus fruits as a basis for further work on citrus quality.

Literature Cited

1. Association of Official Agricultural Chemists. Official and tentative methods of analysis. Ed. 2. Wash., D. C. 1925.
2. Chase, E. M., and Church, C. G. Composition of Marsh seedless grapefruit grown in California and Arizona. Calif. Citrograph., 9:122–123; 134; 164; 198–201; 220; 248. 1924.
3. Collison, S. E. Sugar and acid in oranges and grapefruit. Fla. Expt. Sta. Bul. 115. 1913.
4. Denny, F. E. Formulas for calculating number of fruits required for adequate sample for analysis. Bot. Gaz., 73:44–57. 1922.
5. Domínquez, F. A. Lopez. Changes wrought in the grapefruit in the process of maturation. Part I. Natural changes. Jour. Dept. Agr. Porto Rico, 4(4); 1–101. 1921. Part II. Factors affecting the composition of the fruit. Jour. Dept. Agr. Porto Rico, 5(4):1–45. 1921.
6. Haynes, D., and Judd, H. M. The effect of method of extraction on the composition of expressed apple juice, and a determination of the sampling error of such juice. Biochem. Jour., 13:272–277. 1919.
7. Hume, H. H. The cultivation of citrus fruits. Macmillan, N. Y. 1926.
8. Onslow, M. W. The anthocyanin pigments of plants. 2d ed. Univ. Press, Cambridge. 1925.

[6]The Triumph (7) apparently has a higher pH range.

9. PALMER, L. S. Carotinoids and related pigments. Amer. Chem. Soc. Mon. No. 9. Chem. Cat. Co. N. Y. 1922.

10. ROBINSON, G. W., and LLOYD, W. E. On the probable error of sampling in soil surveys. Jour. Agr. Sci., 7:114–163. 1915–16.

11. ROBINSON, T. R. The bud-sport origin of a new pink-fleshed grapefruit in Florida. Jour. Hered., 12:195. 1921.

12. HENRY, A. M. The chemical composition of Florida oranges. Fla. Dept. Agr. Quart. Bul. 23(2). (Pt. 2), 53:29–30. 1913.

13. SHAMEL, A. D. Origin of a grapefruit variety having pink-fleshed fruit. Jour. Hered., 11:157. 1920.

14. SWINGLE, W. T. [Classification of citrus fruits.] *In* Sargent, C. S., ed., Plantae Wilsonianae . . . Arnold Arboretum Pub. No. 4 (Pt. 4):141–151. 1914.

15. SWINGLE, W. T. Classification of citrus fruits. In Bailey's Standard Cyclopedia of Horticulture. New ed. 3 vols. Macmillan. N. Y. 1927; pp. 780–785. 1919.

16. TRAUB, H. P., and FRAPS, G. S. Ripening and composition of the Texas Magnolia fig. Preliminary Report. Proc. Amer. Soc. Hort. Sci., 25:306–310. 1929.

17. U. S. D. A., Plant Quarantine and Control Administration. Citrus census of the Lower Rio Grande Valley of Texas as of July 1, 1929. Service and Regulatory Announcements No. 100, July–Sept., 1929. 1929.

18. VAN SLYKE, D. D. On the measurements of buffer-values and on the relationship of buffer-value to the dissociation constant of the buffer and the concentration and reaction of the buffer solution. Jour. Biol. Chem., 52:525. 1922.

19. WAYNICK, D. D. Variability in soils and its significance to past and future soil investigations. I. A statistical study of nitrification in soils. Univ. Calif. pub.. Agric. Sci., 3:243–270. 1918.

Suggestions from Spraying Investigations

By T. J. TALBERT, *University of Missouri, Columbia, Mo.*

IN an effort to find more effective and suitable sprays for the control of diseases and insects injurious to orchard trees, the Missouri Agricultural Experiment Station has during the past seven years given particular attention to the testing and investigation of many different kinds of sprays and spraying materials. Among the various spraying chemicals, oils have been found to be very promising.

This has been particularly true in regard to dormant sprays for the control of San Jose scale and other scale insects. Moreover, oil applications when applied early in the spring as growth starts and when aphid eggs are hatching have been found to be as effective as any sprays used in the control of this pest.

Combination sprays, including oil, have been used throughout the spraying season in the applications made for the control of diseases and insects harmful to the fruit and foliage of the apple. Summer dilutions of oil alone have been used late in the season for the purpose of controlling late attacks of codling moth and to prevent accumulations of spray residue on the fruit just before harvesting.

A brief summary of results follows:

1. Dormant applications of oil sprays for a period of six years have controlled San Jose scale and other scale insects on apple, pear, peach, cherry, and plum trees without injury to the trees. No accumulative injury has been noted.

2. Two types of oil emulsion combination sprays have continued to be used successfully at the delayed dormant and pre-cluster bud periods for apples. The first has consisted of bordeaux made according to the 3–4–50 formula, a 2 per cent cold-mix lubricating oil emulsion, and 1 pound of dry arsenate of lead. The second has been lime-sulphur, cold-mix oil, and arsenate of lead, consisting of lime-sulphur 1½ to 50, a 2 per cent cold-mix lubricating oil emulsion, and 1 pound of dry arsenate of lead. These sprays have been applied to Jonathan, Grimes, Delicious, York, Ben Davis, Gano, Stayman, Rome, Winesap, Ingram, Willow and other apple varieties. The amount of early growth or development at the time of application has ranged all the way from bud swelling up until the cluster buds separated, but before the blossoms opened. While in some cases slight injury has occurred, especially to the margins and tips of the young leaves, in no case has it proved serious. Both of these combination sprays have proved to be very effective against San Jose scale, aphids, apple scab, black rot, leaf spot, canker worm, curculio, etc.

3. During the six-year period of making applications of 1 per cent cold-mix oil in the standard sprays applied throughout the spring and summer spraying season, the most injury has uniformly occurred during the early part of the spraying period and generally at the so-called calyx application.

4. There is a great variability as to oil injury on the different varieties of apples. Some of the sorts most susceptible to injury are

Rome, Grimes, Jonathan, Missouri Pippin, and Benoni. The Winesap group, Delicious, Gano, and Ben Davis appear to be more resistant to foliage and fruit injury.

5. After the calyx period, 1 per cent cold-mix oil emulsion did not appear to give serious injury when used in combination with fungicides and insecticides.

6. Vigorous young trees or old trees making considerable twig and leaf growth have usually shown much less foliage injury than trees making slow or little growth.

7. Considerable spray injury on both fruit and foliage has occurred when oil applications, consisting of the different types of lubricating oil emulsion (both cold and boiled) and also when proprietary oil sprays have been used after the usual schedule of fungicidal and insecticidal sprays were discontinued. In fact, the injury has been severe enough to justify questioning the advisability of using oil applications for late codling moth control and to reduce the amount of spray residue.

8. Applications of 2 per cent lubricating oil emulsion in 3–4–50 bordeaux applied to peach trees before any growth starts have given good control of peach leaf curl. Two per cent applications of cold-mix oil emulsion in lime-sulphur (testing 33° Baume) used at a dilution of 4 gallons to 46 gallons of water have also given satisfactory control of peach leaf curl.

9. When lubricating oil emulsion first came into use, 1921–23, many growers and even some Experiment Station workers in the Central States were firm in their belief that concentrated lime-sulphur solution, 1 to 7 or 1 to 8, could not be depended upon for the control of San Jose scale. The Missouri Station has continued to find, however, that lime-sulphur 1 to 7 will control scale if properly applied. Moreover, it has also found that those who are unable to get satisfactory control with lime-sulphur are just as likely to fail with oil sprays.

10. Dry lime-sulphur has continued to give equally as good control of apple scab when used at the rate of 4 to 5 pounds to 50 gallons of water as lime-sulphur when used at a dilution of 1¼ to 50. Moreover, in practically every instance the dry product has given less russeting and a higher finish on the fruit of the apple. Less foliage injury has also occurred through the use of the dry product.

11. Late infections of apple blotch, sooty blotch, fly speck, and bitter rot when serious have been controlled better through the use of bordeaux 2–4–50 than with lime-sulphur ¾ gallon to 50.

12. In the Station orchard as well as in commercial orchards of Missouri, a schedule of spraying which allows for applications at intervals of about 12 to 14 days up until near August 1, or about 4 to 5 weeks of harvest time has in general given the best results for both disease and insect control.

13. The spray residue problem continues to give Missouri growers some concern, although the amount of poison on the fruit, where 7 or 8 sprays have been made, has continued to fail to affect the appetites

of consumers. Moreover, with this many sprays the fruit of most commercial orchards has contained arsenic generally less than .01 grains per pound of fruit.

14. The top fourth of the tree is most likely to be poorly or inefficiently sprayed. Several times as many scabby, wormy, and blotched apples are found in this topmost portion as are found on the lower branches. This has been found to be generally true in both experimental tests and especially in commercial orchards.

15. Where insects and diseases are serious in apple orchards, sprays have uniformly given better results than dusting.

16. Results show a tendency toward more dilute summer sprays and more thorough spraying.

Some Big Results of Horticultural Extension

By C. P. Close, *U. S. Department of Agriculture, Washington, D. C.*

HORTICULTURAL extension as a Federal project was started 16 years ago. A few of the states were then doing some horticultural extension work on their own funds. During the first year of Federal help (1914–15) 16 states allotted $29,927.89 to this work. In 10 years the annual allotment increased to $315,353.61 and the number of states to 38. Six years later (1929–30) the annual allotment of 44 states was $418,438.39. During the entire 16 years the total state allotments amounted to $4,041,414.07 for the work of state specialists. Besides this amount considerable sums have been used by county agents and home agents, but there is no way of determining how much. Few figures are available on the approximate cash value of results obtained, but Kansas claims $842,000 profits on horticultural extension in 1928, and Texas claims $390,000 benefit for the same year. California claims $13,800,000 benefit in orchard heating and tillage. These three items total nearly four times the entire allotments of all the states in 16 years.

In assembling results for this address each specialist was asked for his big results in the past five years. Several replied that they did not have anything big to report. A few made no reply. To those who did furnish information I wish to express my sincere thanks and appreciation. The credit for big results accomplished goes to the states and to the men who did the work.

The intent was to cover the period of five years beginning with 1924 and ending with 1928. This could not always be done but when any other period of time is considered it is specifically mentioned.

In The Eastern States

One big piece of cooperative work is that of six of the New England States, namely, Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island. They agreed that a common problem upon which all would work in harmony was the elimination of odd and worthless varieties of apples. They adopted as the best commercial varieties these seven, namely, McIntosh, Baldwin, Wealthy, Gravenstein, Delicious, Rhode Island Greening, and Northern Spy, to be known as the "New England Seven" which they will urge for new plantings and for topworking in all sections where one or more of them will succeed. Thirty-five thousand trees of odd varieties were top-worked to the "New England Seven" varieties in 1928 and a good many trees of poor varieties were taken out. In Massachusetts the eliminating of unprofitable varieties of apples and the topworking of thousands of trees to the "New England Seven" is a big accomplishment.

The potato work in Connecticut is estimated to be worth nearly half a million dollars to the potato growers of the state in recent years. In one county alone 36,000 bushels of certified seed were planted on new potato acreage. Another rapidly developing piece

of work is that of plant-growing sash houses and greenhouses of which 400 or more have been built in connection with extension demonstrations.

In New York the use of the two-thirds celery crate was so effectively demonstrated that in 1927 it was made the legal standard by legislation. At an estimated increase in value of 50 cents per crate the value added to the celery crop is about half a million dollars per year. The use of the best demonstrated strain of cauliflower seed increased the crop value at least $40,000 last year.

A big potato improvement campaign was launched in three counties in the fall of 1928 to prepare for starting work in 1929. A total of 553 survey records were made. One hundred and seventy-five growers in one county treated 60,000 bushels of seed potatoes, and 27 in another county treated 14,000 bushels. Figures for the other county are not available, nor are total yield records available.

Changing economic fruit conditions in New York made it desirable for fruit growers, fruit organizations, the farm bureau, and university men, to hold conferences and decide upon a state wide plan of work to put fruit growing on a stable basis. It was recommended that under extension leadership poor trees, odd varieties, old neglected orchards, and crowding filler trees should be eliminated; standard varieties used; better orchard economy practiced; the apple grading law enforced; shipping point inspection increased; and poor grades kept off the market. This program is being pushed vigorously.

Five years ago Pennsylvania started work with demonstration plant-growing sash houses for early truck crops. Up to date more than 500 of these sash houses have been built and early trucking has been revolutionized. Allegheny County in Pennsylvania is the leading sweet corn county of the state. Until three years ago the sweet corn varieties used were very indifferent and poor, but now the entire industry is using the varieties recommended by the extension service.

The landscape demonstrations of the past five years in Maryland number more than 200 and the people reached in landscape work number more than 12,000.

In fruit work the pruning practices have been changed as has also the use of fertilizers. Nitrogen is now being used in most commercial orchards. Fruit thinning and the use of cover crops are increasing.

In The Southern States

In four years 40 sweet potato home storage and curing houses with a capacity of 101,000 bushels have been built in Virginia. Half of these are in Princess Anne County and the growers received 50 cents to $1.00 per bushel premium over the price of bank-cured sweet potatoes.

In fruit work the spray service which reaches 4,500 fruit growers is about the most important. It is administered by horticulture with the advice and help of entomology and pathology.

In Kentucky, Professor J. S. Gardner invented a dust gun for Mexican bean beetle control. He induced a dealer to have the gun manufactured in 1928, and 6,000 were sold within the state and 5,000

outside the state the first year. Professor Gardner also arranged with the same dealer to manufacture calcium arsenate dust for beetle control to sell at 15 cents per pound. Kentucky used 120,000 pounds and other states used 90,000 pounds the first year. This means the use of 105 tons of poisoned dust and 11,000 dust guns in one year as the result of one piece of extension work.

In the fruit work there was an opening for a dewberry industry in several counties and it was launched. It started off with 15 cars in the first crop and prospects of increased plantings. In the cooperative marketing of strawberries 2,500 growers in seven counties have been kept in harmonious marketing relations between their local organizations.

In South Carolina the peach industry has increased from 20 cars in 1920 to 723 cars in 1928 as a result of demonstrations. Home gardening work is growing rapidly and there were 236 complete garden records and about 200 in sweet potato work made in 1929.

The landscape specialist in Georgia has drawn 664 plans for demonstration homes, schools and other public buildings, and has assisted in the improving of 959 other properties, making a total of 1623 properties worked with in five years.

The work in the "All year" gardens in Alabama has been growing rapidly since 1924, and in 1928, 8,236 women and girls were enrolled in garden work. Partly as an outgrowth of this garden work 26 curb markets were organized in cities and towns and garden crops amounting to $843,562 were sold in 1928. Much of these sales was the surplus from the "all year" gardens.

In Mississippi the landscape work is outstanding. In four years, 1925 to 1928 inclusive, there were 22,156 members enrolled in home beautification work and 13,517 grounds were beautified in some way. Of this number 2,062 homes and 454 school or community grounds were planted according to definite landscape plans. In 1929 in eight counties there were 1,598 homes improved by landscape plantings, the number in each county varying from 120 to 383.

The home garden work is going even stronger than the landscape work. In 1925, 1926, 1927 and 1928 there were about 35,000 people enrolled in home garden work and of these more than 10,000 grew winter gardens for the first time.

The Louisiana State Triumph certified seed potato buying pool conceived and developed by Professor G. L. Tiebout, is one of the biggest pieces of horticultural extension work that has proved a success. This was done in cooperation with the state farm bureau which acted as purchasing and distributing agent. In 1925 to 1929, inclusive, 266 cars of certified Triumph seed were purchased and distributed through this pool to growers. Besides these there were many cars of certified seed used as a direct result of extension publicity and handled by seed firms.

The hot formaldehyde treatment of seed potatoes at cooperative central treating points began in 1926 with two cars. In the three seasons following, 145 cars were treated cooperatively.

In East Baton Rouge Parish or County the home demonstration

agent, Miss Deshotels, obtained records from 781 all-year gardens in 1928. The sales of garden truck from these gardens amounted to $46,860.

In Arkansas the use of oil emulsion in spraying demonstrations made to control the San Jose Scale involved 553,732 trees in 1925, 1926, 1927 and 1928. The total number of demonstrations made in this spraying work during these years was 1,458. It is estimated that 521,319 peach trees were saved by the spraying just mentioned, including those saved in 1929. The work in landscaping has been increasing very rapidly and during the summer of 1929 about 1200 demonstrations were made. In a State wide landscaping contest 500 homes were entered.

In Oklahoma the home agents cooperated with the extension horticulturist in conducting home garden work. There were about 500 women's garden clubs with approximately 10,000 farm women members in 1928. Of these 2,783 entered the garden contest and of this number 2,155 had gardens worthy of competing for prizes. The number of complete garden reports handed in was 890.

In Texas in 1924 a campaign of pecan budding was carried on in 10 counties and 732 men were taught how to topwork native pecan trees. They set 188,000 buds on 65,000 native trees. One year later 63 per cent of the buds were alive on 40,950 trees. In 1925 and 1926 the pecan budding demonstrations resulted in the working over of 11,102 acres of native trees. This included the thinning out of surplus trees, and cutting back and budding those left. One hundred thousand native trees in 69 counties were budded and the surplus trees were removed in 1927. In 1928 the top-working of pecan trees to improved varieties extended to every section of the State and included more than one-quarter of a million trees.

Better practices in the care of citrus fruits were adopted for 29,150 acres in 1924, 1925 and 1926, and nearly one-half million citrus trees were planted under the instruction of extension teaching in 1928 in the Rio Grande Valley.

In The Central States

The biggest horticultural project in Michigan is Hootman's fruit blossom pollination work by use of honey bees. In 1928 about 8,000 colonies of bees were introduced into orchards during the blossoming period. In 1929 about 14,000 colonies were used in approximately 25,000 acres of orchards with an estimated increase in yield of fruit of from 10 to 15 per cent. Assuming only $10 per acre increase in returns this means $250,000 added to the value of the fruit crop in one year. In one cherry orchard the increased yield was 68 tons worth $7,000. In one apple orchard the increase in crop was 2400 bushels of McIntosh and in another it was 3,700 bushels of Northern Spy.

The introduction of strawberry growing into Orange, English, Jasper, and Daviess Counties in Indiana was done in 1927 and 1928. About 125 acres of Aroma berries were planted on 100 farms the first year. This made it possible to ship in carlots in 1928 and about $16,000 was realized from the first crop.

In Illinois about 90 per cent of the fruit growers are using commercial fertilizers intelligently. Three-fourths of the peach growers are pruning according to extension teaching. Fruit grading and packing are making vast strides and Federal and State inspections have multiplied sevenfold.

The outstanding piece of work in Wisconsin is the organizing of orchard spray rings. In 1924 there were 90 of these rings and the number has grown to 171 located in 29 counties in 1929. There are about 2,000 farmers in these spray rings. In some of the counties the spray rings are united into county fruit growers' associations. These associations buy spraying materials, packing equipment and nursery stock cooperatively for the members. They also handle surplus fruit grown by the spray ring members. The average net income from farm orchards of from 25 to 50 trees has been increased from $100 to $300 as a result of membership in a spray ring.

In fruit work in Iowa the orchard spray service is outstanding. From 1912 to 1925 over two hundred result demonstrations in spraying were completed, and the need of spraying was pretty well learned by fruit growers and farmers. This work developed into a spray service which served 10,590 farmers in 49 counties in 1927. In 57 counties, 15,705 farmers were served in 1928, and in 1929 in 64 counties, 18,150 farmers received the spray service. The fruit specialist prepared the spray notices for the county agents to send to farmers, the publicity for the press, and talks for radio broadcasting. In cooperation with the extension entomologist seven codling moth stations were established in different parts of the State to get readings for timing the spray notices.

South Dakota is strong on home vegetable and fruit garden work. In 1927 the specialist trained 35 county agents to carry on training and demonstrations in garden work. There were over 700 women's clubs in the State and two members of each club were selected to receive instruction as demonstrators. This teaching was done at 121 extension schools. The specialist trained 559 demonstrators, but it is not known how many the county agents trained. These demonstrators conducted demonstrations before 517 women's clubs with an attendance of 6,783. There were 1,335 home gardens actually planted and balanced according to the advice given at the demonstrations. About an equal number of home gardens were sprayed according to directions given. Better cultural methods were adopted in 1,683 gardens, and there were 4,558 homes directly influenced by this garden work.

As a result of 120 grape pruning demonstrations in Kansas in 1928, 300 growers pruned 844 acres according to the long cane system. In orchard work 94 cooperators pruned and sprayed 272,595 trees. Spray service letters were sent to 2,900 orchard owners. The estimated value of horticultural extension in 1928 is, for commercial orchard management $400,000; for orchard development, $200,000; for home orchards, $135,000; for grapes, $100,000; for acre orchards, small fruits and vegetables, $7,000; making a total of $842,000.

In Nebraska 802 leaders have been trained in landscape work and 8,013 homes have been improved by landscape plantings. The Ex-

tension Service spraying program for apples has been adopted by practically all of the apple growers of the state. The 2,000 acres of new commercial apple orchards set out in the last five years are being pruned to the modified leader type. Varieties susceptible to blister canker are no longer used.

In The Western States

Colorado reports on the 600 bushel per acre potato club work organized in 1927. There are already about 25 growers who have qualified for membership and in 1929 one of them broke all American records with an acre yield of 1145 bushels.

In New Mexico the truck crop work seems to have given bigger results than the fruit and landscape work.

In the citrus work in California the serious scaly bark disease of orange trees has been practically controlled. Orchard heating in some sections of California has been practised many years, but other sections would not adopt it because that would be an admission that the section was frosty. Some communities had to be convinced, and the Extension Service did most of the convincing. Covina was one and it now has four-fifths of its citrus acreage equipped with heaters, with an estimated benefit of $5,000,000. Redlands was another which now has more than half of its citrus acreage heated with an estimated benefit of $7,000,000. The knowledge of these results spread to deciduous fruit growers and led to the use of orchard heaters on more than 1,000 acres, thereby saving the 1929 crop valued at $800 per acre. In Orange County citrus tillage costs have been reduced from $30 to $12 per acre. This benefit extends to 100,000 acres of citrus with an annual saving of more than $1,000,000 most of which is due to horticultural extension efforts. This influenced peach culture in Stanislaus County where tillage costs were reduced from $23 to $8.85 per acre.

In the Persian walnut work the winter irrigation of 65,000 acres of walnut orchards is largely due to extension activities as is also the control of aphids, codling moth, and red spider on 18,000 acres of walnut trees. Approximately 80 per cent of both old and young walnut trees are now pruned according to the teaching of the extension service.

The seed potato certification work in Idaho from 1925 to 1929 inclusive covered 16,569 acres which passed the second field inspection and yielded a total of 1,996,104 bushels.

Home Gardens

There is nothing in horticultural extension that is creating more active interest and results than home gardens. Nutrition work has stimulated thousands of people to eat more vegetables and the home agents, county agents, club agents, and state specialists, are cooperating in a vigorous campaign for more and better gardens and particularly all-year gardens where they will succeed. In 1927 and 1928 there were 63,732 people growing all-year gardens for the first time.

The Southern states lead in garden activities. Of the hundreds of records available only a few can be given here.

In Mississippi one half-acre garden netted $522.10 one year and $666.95 the next year. Another 66 x 100 feet in size fed seven people all season, had 28 different kinds of vegetables growing on November 1, had produced crops for canning and winter storing, and a surplus which sold for $236. Another one 110 x 129 feet grew 25 kinds of vegetables, fed four people and of the surplus $97 worth was sold and $65 worth was canned. Another 100 x 125 feet fed a family of 8, and after $25 worth was canned, the rest sold for $593. 34. This is at the rate of $1855 per acre for the surplus.

South Carolina has 49 records of gardens averaging nearly half an acre in size which fed 271 people and after 3004 quarts of vegetables were canned the balance of the crops was sold for $3,690. One quarter-acre garden produced enough to feed 10 people all season, to can 450 quarts and to sell $220.30 worth.

This part of the address would not be complete without giving the experience of one 4-H Club girl in Arkansas. Gertrude Turk, a thirteen year old girl, had a one-twentieth acre garden of tomatoes, lima beans, beets, cucumbers, and greens. She fed a family of seven all season, sold $28.50 worth of vegetables, and canned 201 quarts worth $51.90. The cost of production was $11.00, thus leaving a profit of $69.40 for this little garden after feeding seven people. She states that she sowed the tomato seed of a 10-cent package, gave away more than 100 plants, planted the rest and supplied the family with fresh tomatoes every day all summer and fall, canned 81 quarts valued at $21.15, and sold $26.50 worth of fresh tomatoes. Thus as she states it a 10-cent package of tomato seed grew into $47.65 with only a little patience and effort.

The Biggest Result of All

It will be a shock to horticultural extension men—though I hope a pleasant shock—to know that the biggest result of all in horticultural extension was accomplished by a woman, Mrs. Dora Dee Walker, production and conservation specialist, of South Carolina. Under Mrs. Walker's enthusiasm and leadership the club women of South Carolina in 1927 and 1928 beautified 170 miles of highway by cleaning up the roadsides and planting trees and flowers. Besides this highway improvement they also beautified 14 community parks, 194 school grounds, 89 church grounds, 27 cemeteries and scores of homes during those same two years. Considerably more than 200 miles of highway are now beautified and the movement is sweeping the state. Mrs. Walker's goal is the beautification of South Carolina highways making them strips of beauty from the mountains to the sea. Her new project of revolutionizing country community life is spreading like wildfire and promises to be the best and most far-reaching piece of community improvement of recent time.

Conclusion

There are undoubtedly many other big results which are not reported here. Those given will suffice to show that horticultural extension has made good. The horticultural specialists may well feel proud of what they have accomplished. Their aim will be for even greater results in the future. To attain these they should have few main lines and hit these so hard that the dent made will never flatten out. Too much time and hard work, have in some cases been given to a long list of projects which scattered the efforts and petered out so that at the end of the year there was little to show for all the work done. The specialists have a vast fund of information to extend and their major effort now should be to reach more people with it than ever before.

Effect of Light, Temperature, and Transpiration on Elongation of Canes of Raspberry and Other Brambles

GEO. M. DARROW, *U. S. Department of Agriculture, Washington, D. C.*

IN breeding work there is a constant search for measures which may simplify the work of selecting the desirable from the mass of seedlings and which may delimit the adaptation of the desirable selections. Among the brambles striking examples of the effect of conditions on adaptation are: (1) The Viking raspberry, which is hardy, even in Quebec, but not in Maryland, while the Latham is hardy both in Minnesota and in Maryland; (2) the Young dewberry which is finer flavored in southern regions than in the North, while just the reverse is true of the Lucretia variety; and (3) the Van Fleet raspberry which commonly makes a cane growth of 8 to 10 feet, while in the hot interior valleys of California its canes may grow 25 to 30 feet. This type of information has resulted from field trials in different localities.

In the breeding work of the Bureau of Plant Industry with Asiatic brambles some of the resulting hybrids have shown desirable characteristics. A better understanding of the conditions affecting the growth and adaptation of each parent species was needed in evaluating the hybrids and resulted in this study of some conditions affecting the elongation of raspberry and blackberry canes. Cane elongation is readily measurable on living plants and its rate may be taken as fairly representative of the rate of growth of the above ground parts, at least when cane elongation is a chief plant activity. Beginning in the latter part of July or in August the new shoots of brambles which propagate by rooting of cane tips make a very rapid growth in length. The weather of late summer in Maryland is variable; cool dry, hot dry, cool moist, or hot moist intervals may occur in succession. It seemed possible by measuring plant response for a period of several days in late summer which is representative of the average or of the critical conditions of other regions to obtain an indication of the growth response of the variety in those regions. In this study the behavior of brambles under conditions of high transpiration rates seemed of greatest significance.

From August 5 to September 14, 1927, elongation of Cumberland black raspberry canes was measured by the use of an auxograph and with a flexible ruler. From September 20 to October 24, 1928, the cane elongation of several species and of two hybrids were measured. For the same periods evaporation rates were obtained by means of Livingston black and white atmometers run in pairs. Thermograph and auxograph records were obtained for both years.

In 1927 the region of elongation of 27 shoots of the Cumberland black raspberry was determined by marking the tips with India ink and measuring the increase in length. The average growth of these shoots for the interval August 5 to September 14 was 13.2 cms. but varied from a growth by four canes of 24.6, 23.1, and 22.9 cms., respectively, to a growth by two canes of less than 1 cm. each. The

region of elongation ranged from the last centimeter next the tip only, to the last 14 centimeters. However, no shoot grew more than .5cm. farther back than 8 cms. from the tip, nor more than 1.0 cm. farther back than 6 cms. Of the tips growing more than 1 cm., the terminal centimeter of the canes averaged a growth of 5.8 cms. in the 7 days, the next 2.9 cm., the third 1.6 cm. and the fourth 1.2 cm. Over 85 per cent of the growth was confined to the last 4 cms. of the growing tip. In taking the records 25 to 55 cms. of shoot were measured and in 14 of 27 shoots contractions (.1 to .4 cms.) of the older portions were noted.

The auxograph records for the Cumberland black raspberry showed a periodic diurnal elongation of extraordinary regularity as follows: Elongation was rapid from daylight till 10 or 11 o'clock; then very slow, the slowest for the 24-hour period till 1 or 2 p. m.; then the most rapid elongation of the 24-hours until about 11 p.m.; and finally slower from about 11 p. m., until about daylight. The ratios of elongation for the different parts of the day, considering the highest rate as 100, were approximately 100 for the afternoon and early night, 60 for the morning, 35 for the middle and latter part of the night and 20 for the middle of the day. Thus there are two maxima and two minima growth periods, each of different values, for the Cumberland black raspberry.

The diurnal march of elongation in August and September, 1927, in the black raspberry appeared to have no direct relation to light. Certainly light had no direct inhibitory effect. Rapid elongation of canes began early in the afternoon when the sunlight was not far from its greatest intensity, while the most rapid elongation of the day was usually during the hours just before dark. Continued rapid elongation for a few hours after dark indicated that absence of light had no effect. The two minima, one in the night and one at midday are further proof of the lack of any direct inhibitory effect of light on these plants. As an example, the growth of a single cane for 12 days and 12 nights was compared. Its daylight elongation (6 a.m. to 6 p. m.) was 19.6 cms., and its night elongation 18.4 cms., a difference not significant.

From September 20 to October 20, 1928, a shoot from each of two hybrid (black x red) raspberries were measured. One shoot grew much more during the day, the other slightly more at night. With each, elongation was sometimes greater at night, sometimes in the day.

Canes of *Rubus innominatus*, *R. ellipticus*, the Himalaya and Oregon Evergreen blackberries, and the Young dewberry were measured from October 16 to October 30. For comparable periods canes of all five kinds elongated more at night than in the day, on the average about 33 per cent in the day and 67 per cent at night. However, for all except *Rubus ellipticus* greater elongation occurred during the day for at least one day. These results further indicate that light has no direct effect on elongation.

For the Cumberland black raspberry high transpiration seems to offer an explanation of the midday slowing down of elongation. The abrupt beginning of a rapid rate of elongation soon after noon

during the hottest part of the day when evaporation is highest would seem to be possible only as a result of the closing of the stomata. With the closing of the stomata, transpiration would be greatly reduced, turgor increased, and elongation speeded up. The products of photosynthesis were apparently available for growth for several hours after nightfall. The second slowing up of elongation just before midnight may indicate that these products were used up or that acidity increased as MacDougal (1) found in the cacti. Turgor apparently was never entirely lost in these plants because growth did not entirely cease at any time.

Healthy plants of the Cumberland black raspberry seem to be very efficient water conductors and adapted to an extraordinary wide range of conditions involving water supplying power. On September 7, 1927, a day with an evaporation rate three times the average rate of the period studied and comparable to that of the deserts of the West, one cane elongated 1.7 cms.—which was just its average daily rate. On August 16 and September 12 evaporation rates of about twice the usual values occurred. Elongation continued throughout both days although very slight on August 16 and at a much slower rate than on days just before or just afterward. However, on August 31, when the humidity was high, the highest growth rate of .7 cms. per hour was recorded.

In the whole 1928 period there was practically no evaporation at night and there was also no day when transpiration was so high as to stop growth. For day-periods with the highest evaporation rates (3.5 c.c. per hour for black atmometer) the average elongation for the hybrid raspberries was slightly above the average for the whole period. Except following the night of a frost there was no day when elongation of the species studied ceased. It was greater on days with least evaporation and greatest on warm nights following sunny days with high evaporation rates.

Elongation of the Cumberland black raspberry canes did not seem to be checked at any of the high temperatures encountered. Rapid elongation occurred even during the first few days of September on days when the temperature was well above 90 degrees F. In 1928 no elongation of canes of any brambles occurred on nights when the average temperature was below 40 degrees F. Average night temperatures of 49 and 50 degrees F. resulted in average elongation. Temperature graphs for the 24 hours showed the typical march from high values early in the afternoon to lowest values just before daylight and did not at all follow the typical double maxima and double minima of the growth rate graphs. Apparently under the conditions in 1927 growth was not influenced primarily by temperature within the range that occurred nor in 1928 until the night temperature went as low as 40 degrees F.

The Oregon Evergreen seemed to be checked more by the onset of cold weather than was *Rubus innominatus* or the Young dewberry, which may be the reason for its slightly greater hardiness. The Himalaya blackberry made the greatest growth of any on hot sunny days with high evaporation rates but was checked the most of any

when the weather was cool. It is known to succeed well in the hot dry valleys of California as well as in the cool districts of the Pacific Northwest. *Rubus ellipticus*, a tropical raspberry, showed rather low day growth rates but higher night rates, and would seem better adapted to humid regions than to the more arid regions. Canes of the Cumberland black raspberry and of red raspberries had already stopped elongating some weeks before cold weather, this being perhaps largely the reason for their much greater hardiness under climatic conditions in northeastern United States.

Summary

Elongation of shoots of brambles was used as a measure of growth of the Cumberland black raspberry and of several other bramble varieties and species. The region of elongation of shoots of the Cumberland black raspberry was in the terminal 17 centimeters but elongation back of the terminal 6 cms. did not total more than 1 cm. The most rapid elongation of this variety for any day was .7 cm. per hour. It showed a periodic diurnal march of elongation of extraordinary regularity of two maxima and two minima, the most rapid from 1 or 2 p. m. until about 11 p. m., a slowing up from 11 p. m. until about daylight, a more rapid rate from daylight until 10 or 11 o'clock and the slowest rate from 10 or 11 until 1 or 2 p. m. Neither light nor high temperature conditions encountered appeared to have any direct inhibitory effect on the growth rate. Elongation was slightly greater during the daylight period than at night for the Cumberland black raspberry. Of two hybrid raspberries one grew slightly more at night, the other much more during the day. Other brambles including *Rubus innominatus*, *R. ellipticus*, the Himalaya and Oregon Evergreen blackberries and the Young dewberry grew more at night, though all except *R. ellipticus* grew more during the day for at least one day. Night temperatures of 40 degrees F. or below checked growth on all brambles observed. High transpiration seemed to offer a partial explanation, at least, of the daily march of the growth rate. The highest elongation rate of afternoon and evening may be explained by the closing of the stomata associated with high transpiration rates; the late night slowing down of the growth rate as possibly due to utilization of photosynthetic products and increase in acidity; the morning increase as due to photosynthesis with low transpiration; and the midday slowing down as due to too high transpiration. In a consideration of the regional adaptation of brambles, their behavior under conditions of high transpiration rates would seem of major importance.

Literature Cited

1. MacDougal, D. T. The mechanism and conditions of growth. Memoir N. Y. Bot. Gard. 6:5. 1916.

A Method for Studying the Relative Rates of Transpiration of Apple Leaves and Fruits

By Arthur J. Heinicke, *Cornell University, Ithaca, N. Y.*

A SIMPLE method of determining quantitatively the loss of water from various parts of the plant and its product was devised in connection with some pruning studies on apple trees. The method is here described since it may prove of interest to others in studying certain aspects of transpiration of plants where it is impracticable to use standard gravimetric methods.

The apparatus consists of a glass weighing bottle, 25 x 40 mm. fitted with a ground glass stopper and a rubber gasket. The gasket is nothing more than a rubber band about 5 to 7 mm. wide, about 1 mm. thick, with an inside diameter of 25 mm. Rubber tubing, similar to that used for Gooch crucibles, may be cut into such bands. When in place, the gasket extends 1 or 2 mm. above the edge of the open end of the bottle and should not interfere with the stopper. About 1 to 2 grams of dry powdered calcium chloride are placed in the bottle after which it is closed with its glass stopper and weighed on a sensitive balance. A large number of bottles may be thus prepared and held in a dessicator until ready for use.

The special clamp for attaching the weighing bottle to the leaf is shown in Fig. 1. This clamp may be made from a wire test tube holder by changing one of the oblong jaws into a circular jaw having an inside diameter about as large as the outside diameter of the bottle (c). The arms of the clamp must be modified so that the circle lies in the same plane and coincides with the outer edge of the opening of the weighing bottle, the side and bottom of which are supported by the oblong jaw (d). Careful adjustment should be made so that the pressure of the clamp is applied equally to all parts of the mouth of the bottle.

When the determination begins, the glass stopper of the weighing bottle is removed and the leaf blade is placed over the open end. It is held in position by the clamp which also presses the bottle against the leaf. The rubber gasket (a) molds itself around the veins and other irregularities of the surface and forms a reasonably tight connection. The rubber also helps to prevent injury that might occur if the leaf were placed between the glass edge and the spring clamp. The time is recorded as soon as the bottle is first attached to the leaf, and again when it is removed. The glass stopper is replaced immediately at the end of the determination, after which the bottle is ready to be reweighed.

In Fig. 1, at A, the weighing bottle is shown in position on the under side of the leaf, and at B, on the upper side of the leaf. The bottles together with the clamp are not heavy enough to cause any constriction in the leaf petiole that might interfere with water movement. The apparatus may be left in place for a fairly long time, or it is possible to study the same leaf or different portions of the leaf at many different, short intervals.

In Fig. 2, the bottles are shown in use on the red side and on the green side of an apple. In this case, the bottles are easily held in

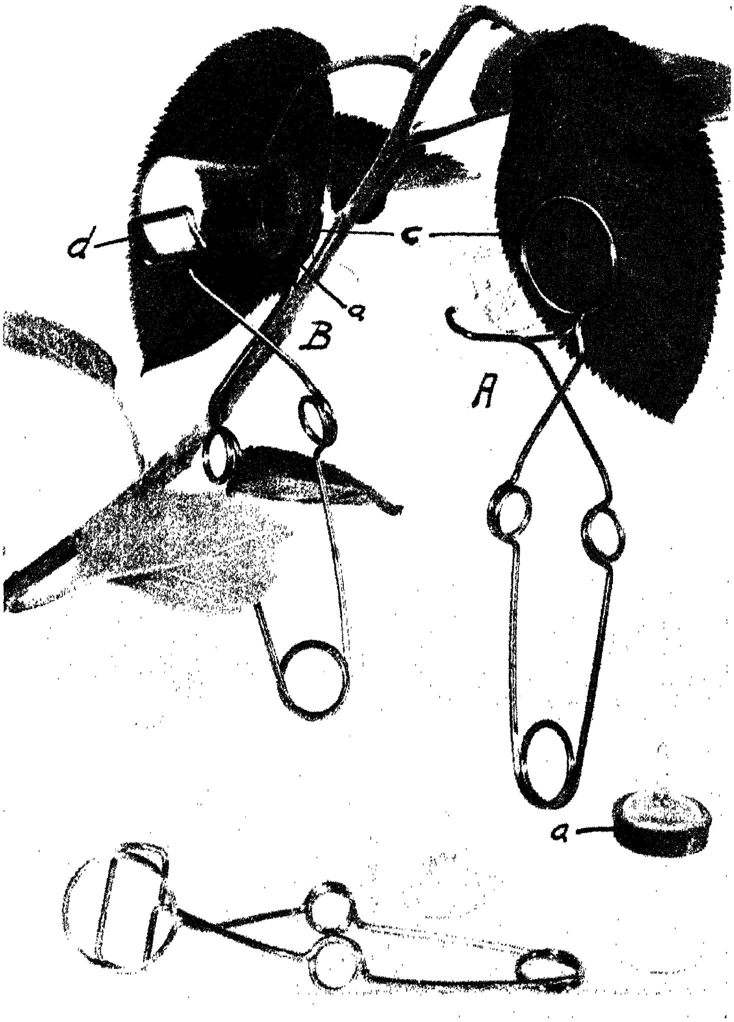


FIG. 1.—The weighing bottles containing calcium chloride and fitted with a rubber gasket are attached to the under or upper side of the leaf blade by means of the special clamp. The increase in weight indicates the amount of moisture given off by the portion of the leaf covering the open end of the bottle.

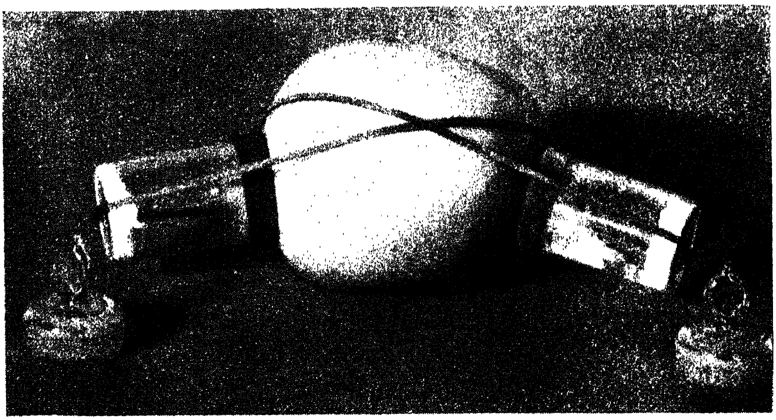


FIG. 2.—Weighing bottles containing calcium chloride attached to the apply by means of rubber bands to measure the water loss from different sides of the fruit.

place by means of rubber bands as indicated. The rubber gaskets help to form a tight connection. The bottles can, of course, be used to study water loss of the fruit which is still attached to the tree.

The method involves no new principles. The moisture that is given off by the transpiring surface is taken up by the calcium chloride or some other non-fuming water-absorbing agent. The gain in weight indicates the amount of water lost by the transpiring surface. The area of the opening of the bottle corresponds to the area of the surface whose water loss is being determined. With the time interval, the area of the transpiring surface, and the amount of water absorbed known, it is possible to express the results in the standard form of grams lost per hour per square meter of surface.

While the method has obvious advantages it is not free from objections. In the first place, the air in the bottle is relatively still so that diffusion of the water vapor would be slow. This may tend to reduce the rate of transpiration. On the other hand, the air in the bottle may be drier than that usually surrounding the leaf and this would tend to increase water loss. Both of these factors, however, would be constant wherever the method is used, and the values obtained would therefore still be a relative measure of transpiration of different tissues, or of the same tissue influenced by factors other than the movement of air and the vapor pressure of water within the bottle. It may be pointed out also that only a small part of one side of the leaf is exposed to the standard conditions leaving the rest of the leaf normal. The values obtained are not as large as they would be if the entire plant or large portions of it were exposed to a dry atmosphere as was the case in Guettard's experiments in 1748. (1).

The absorption bottle method has certain advantages over Stahl's cobalt chloride method. (2). In the first place the results can be expressed quantitatively without the use of color standards. (3.) In the second place the absorbing agent has considerable reserve capacity, and being placed at some distance from the leaf, the rate of absorption of water is likely to be more or less uniform thruout the determination. The layer of air nearest the leaf would, of course, tend to be more saturated than that near the calcium chloride as previously mentioned. The most important advantage, however, is the fact that the light conditions are nearly normal. It is well known that exposure to sunlight is an important factor in transpiration and some of the studies with apple leaves indicate that the rate may be modified immediately and markedly by changes in light intensity.

In order to determine the efficiency of the method just described some apple shoots about 5 mm. in diameter at their basal ends were cut from the tree and then fixed to a potometer. At the same time absorption bottles were attached to the upper and to the lower sides of several leaves on each shoot. It was thus possible to measure the total amount of water taken up thru the cut end of the shoots and also to measure the amount given off by definite areas of certain leaves on these shoots. The experiment was set up for 24 hours in the laboratory, (shaded during the day) where the average tem-

perature was 17°C. The leaf area was obtained by a planimeter, the total transpiring surface being regarded as twice the leaf area.

The average rate of water taken up by the 4 different shoots was 25.2 gms. per hr. per sq. M. of transpiring surface. The average amount of water absorbed by the calcium chloride bottles was 30.3 gms. per hr. per sq. M. If the value obtained by the volumetric method is regarded as 100, that obtained by the absorption method is 122.

The following typical result well serves to suggest the application of the method in studies of interest to the horticulturist. The average rate of loss from the lower surface of the apple leaves in the laboratory during a 24 hour period was 23.2 gms. per hr. per sq. M., and for the upper surface only 7.1 gms. In another case, the average loss of water per sq. M. per hr. from the upper side of yellowish leaves on excised twigs amounted to 8.33 gms. as compared to a loss of 5.58 gms. from the upper side of dark green leaves. On the under side the yellowish leaves lost 23.5 gms., while the green leaves lost 23.0 gms. These relationships do not necessarily hold for shorter periods and if the leaves are exposed to the sun.

On August 21, 1929, between 10 a. m. and 3 p. m. with a temperature of 80°F. and the leaves exposed to the sun for most of the period, the rate of transpiration was 120.4 gms. per hr. per sq. M. Between 3 and 6 p. m. on the same date, the same leaves now in the shade lost at the rate of only 11.4 gms. per hr. The maximum rate obtained on the under side of vigorous Northern Spy leaves exposed to the sun and attached to the tree was 148.04 gms. as compared to 98.6 gms. for an adjoining weak tree under similar exposure. Corresponding values for McIntosh on the same day were 145.6 gm. and 97.1 gms. respectively.

Fruits of McIntosh apple attached to the tree on Sept. 25, 1929, lost during a cool period of 24 hours an average of 9.2 gms. from the red side exposed to the sun for part of the day, and 11.3 gms. from the green cheek. In fruits detached from the tree the red cheek exposed to the sun during the same period lost 22.1 gms. per hr. per sq. M., while the shaded green cheek lost 13.5 gms. The loss from the leaves on the fruit-bearing spurs at the same time amounted to 44.0 gms.

The values given above are in line with those obtained by investigators using other methods of studying transpiration. While this simple absorption method of measuring transpiration may not give absolute values, there can be no doubt that it is a convenient means of obtaining data in studies involving comparisons in the rates of water loss whenever the entire plant cannot be used.

Literature Cited

1. Maximov, N. A. The plant in relation to water. 107. 1929.
2. Stahl, E. Einige Versuche über Transpiration and assimilation Bot. Zeit. 52: 117. 1894.
3. Livingston, B. E., and Shreve, Edith. Improvements in the method for determining the transpiration power of the plant by hygrometric paper. Plant World 19:287. 1916.

A Study of Soggy Breakdown and Some Related Functional Diseases of the Apple

By H. H. PLAGGE, *Iowa State College, Ames, Iowa.*

ONLY during rather recent years has much attention been directed to the correct diagnoses of certain functional diseases of apples. The most common characteristic of such diseases is an indefinite degree of browning or darkening of a part of the apple tissues. All brownish tissues, however, do not consistently show the same degree or intensity of discoloration and cannot be taken as the only index for differentiating between diseases. Most of the functional disorders of apples have been named largely on the basis of external or internal appearances with little consideration of the exact cause of the disease or even of the factors which contribute to its development. A history of the conditions to which the apple has been subjected is very useful and in some cases essential for a correct diagnosis. Different varieties having the same disease may not exhibit the same symptoms. Diseases must be diagnosed before secondary rot fungi alter initial appearances. These facts have produced the confusion which exists among horticulturists and storage operators on apple storage diseases. It is the purpose of this paper to bring together some of the knowledge of this subject to assist in differentiating between some of the common functional apple diseases.

SOGGY BREAKDOWN

In soggy breakdown there is softening and browning of tissue in the cortical portion of the apple slightly beneath the skin in such varieties as Grimes, Wealthy, and Golden Delicious. In typical cases a layer of white unaffected tissue lying next to the skin bridges over the soft soggy brown sections below. Severely affected apples are readily detected by a characteristic springiness. A considerable portion of the fruit becomes involved in the later stages, although the core region usually remains unaffected. The brown soggy tissue is watery in appearance, has a distinct alcoholic taste and when first removed from storage is not mealy. Small apples are susceptible to the trouble as well as the large.

Under this same category should be included the soft-scald type of breakdown common in Jonathan, Northwestern Greening, Rome Beauty, and other varieties. This is characterized by irregular, brown, soft, blister-like areas on the surface of the apple, typical cases having the flesh involved to a depth of 5 to 7 mm. The affected areas vary in size from small dots to spaces covering most of the surface of the fruit. Frequently odd shaped patterns form which partly or completely encircle unaffected tissues. The latter then resemble peninsular or island-like formations in contrast to the broken down dead tissue.

In some varieties (Golden Delicious and Wealthy) both types of soggy breakdown occur simultaneously on the same fruit, indicating that the chief difference between the soft-scald type and the soggy

breakdown type is that of position within the apple. The two have many common characteristics and must now be considered as identical.

The chief cause of these breakdown types is too low storage temperature. The disease occurs commonly at the temperatures now used in commercial practice (31 to 32 degrees F.) At a temperature slightly lower (30 degrees F.) the disease is greatly intensified. A marked difference exists in variety susceptibility. Grimes and Golden Delicious are very susceptible, Jonathan is moderately susceptible, and some varieties as Delicious and Willow Twig appear to be not at all susceptible. Maturity and exposure to room temperatures before storing have a marked influence on its development. Soggy breakdown can be best controlled by storing susceptible varieties at 36 degrees F.

In earlier experiments we have shown that delayed storage increases susceptibility to soggy breakdown, at least on apples held up to three weeks at orchard temperatures (6). We have indicated also that soggy breakdown does not ordinarily appear under common storage conditions. An experiment to determine just where in the life of the apple susceptibility ends, if it does end, was carried out last year. In this experiment the temperature during delayed storage was maintained at 50 degrees F. as this approached the mean temperature to which apples are commonly subjected while left in the orchard. The experimental lots were Grimes wrapped in oil wraps, packed in standard boxes, and placed at 50 degrees F. the day they were picked, except those to be stored directly at 30 and 36 degrees F. One box was placed at each of the two temperatures at exactly weekly intervals starting from the picking date, September 25, until after the twelfth week. The apples were taken from cold storage on January 25th for inspection. Table I gives the experimental results.

TABLE I—COMPARISON OF THE AMOUNT OF SOGGY BREAKDOWN OCCURRING ON GRIMES AT VARIOUS TEMPERATURES. EFFECT OF DELAYED STORAGE AT 50°F. WITH SUBSEQUENT STORAGE AT 30, 32 AND 36°F, 1928–29.

Lot No.	No. of Weeks Delay at 50°F.	Percentage of Breakdown			Percentage of Apple Scald		
		30°	32°	36°	30°	32°	36°
1	0	3.8	0.4	0.4	0.0	0.0	0.0
2	1	0.8	6.5	0.6	0.0	0.0	0.0
3	2	67.8	73.5	4.0	0.0	0.0	0.0
4	3	60.3	67.9	8.7	0.0	0.0	1.7
5	4	63.4	69.3	21.4	6.3	0.0	0.6
6	5	68.5	38.0	8.1	5.3	26.9	40.0
7	6	0.7	3.5	0.0	28.6	23.9	10.8
8	7	0.8	0.0	0.0	23.7	21.7	14.2
9	8	0.6	0.0	0.0	37.4	37.8	11.1
10	9	0.0	0.0	0.0	29.9	42.7	48.8
11	10	0.0	0.0	0.0	62.2	52.0	53.5
12	11	0.0	0.0	0.0	78.6	57.2	51.0
13	12	0.0	0.0	0.0	82.5	72.9	73.8

Susceptibility to soggy breakdown increased with delayed storage with each week of delay until the fourth and fifth weeks, after which there was a very marked decrease. Breakdown susceptibility was

highest when the apples were delayed from two weeks to five weeks inclusive. It was much higher at 30 and 32 degrees than at 36 degrees F. At the last temperature it was 21.4 per cent when the delay was four weeks, but in most cases little breakdown developed regardless of treatment before cold storing.

The detrimental effect of low temperature appears to reach a maximum when the respiration rate and accompanying metabolic changes reach the peak of highest activity. Studies of the respiration rate of these apples by Harding (2) on similar lots in large respiration chambers, show that this is the case, at least in respect to the respiration rate. Pressure tests also show that the ripening changes, as indicated by softening, reach a maximum stage which is identical to the interval when susceptibility to breakdown was highest, after which, these changes go on more slowly. The data on apple scald indicate that when the apples become no longer susceptible to soggy breakdown, they become more susceptible to apple scald; Low temperature (below 50 degrees F.) is important in the control of apple scald even when oiled paper wrappers are used.

Mealy Breakdown

Mealy breakdown, which has been designated by such terms as "old age decay," "physiological decay," "internal breakdown," "senescence," "Jonathan breakdown" (in Jonathan) and recently by Kidd and West (4) as "inherent internal breakdown" is the kind of breakdown in which the flesh of the apple changes from a hard, firm, juicy condition to a softer, mealy and dry consistency. It is common in fruit which has been held too long in storage or at a too high storage temperature. The skin and outer peripheral portions of affected fruit frequently burst, although bursting does not necessarily accompany mealiness.

Mealy breakdown may not always show brown discoloration when removed from storage, but as mealiness increases some external and internal change in color commonly takes place. Varieties differ greatly in the amount and in the location of this discoloration. In Jonathan and McIntosh it begins directly under the skin and spreads toward the core; in Grimes and in York the initial stages occur in the pith region. It frequently follows soggy breakdown, bitter-pit, water core and other unfavorable conditions within the apple. Since mealy breakdown is primarily the result of senility in the apple, its occurrence cannot be postponed indefinitely.

Internal Browning

Internal browning investigated by Overholser, et al, (5), and by Ballard, Magness and Hawkins (1) is largely confined to the Yellow Newtown and to the Pajaro Valley district of California. It is almost entirely a cold storage trouble occurring at temperatures below 37°F., increasing with delayed storage, with late picking and with nitrogen fertilizers. Its appearance differs from soggy breakdown chiefly in that during the early stages the flesh browning remains firm, while in soggy breakdown the flesh becomes soft.

It differs further in that the diseased areas as seen in cross section occur in somewhat elongated areas radiating from the core region. In soggy breakdown this radiating arrangement of brown tissues is not apparent as they extend in another plane perpendicular to lines extending out from the carpels. Frequently internal browning appears only in the core region, the other tissues remaining sound. Soggy breakdown affects the core region only in the last stages of the disease.

Brown Heart

After investigating the feasibility of storing apples in carbon dioxide in England, Kidd and West (3) described another functional disease which they called brown heart. This disease was found to be caused by exposing apples to high concentrations of carbon dioxide in the presence of a certain amount of oxygen. Later these investigators observed considerable amount of brown heart in fruit which had been sent from Australia to England. Apples stored with inadequate ventilation, where there was an excessive accumulation of carbon dioxide, became severely affected with brown heart. The carbon dioxide was more injurious at the low temperatures employed in the storage of apples. Brown heart may be produced by coating apples with paraffin before placing in storage.

Kidd and West (3) stated that brown heart results in the browning and death of a part of the internal fleshy portion of the apple. In slight cases, small patches of brown tissue occur. These are isolated, sharply defined and often numerous. They may occur in the cortex, in the pith or in both. Often they appear to originate in the main vascular bundle tissue. In severe cases a large portion of the internal part of the apple becomes affected, though the outer tissues may still appear normal. The affected tissue is sharply marked from the sound tissue. Badly affected specimens are easily identified by a springiness due to the underlying brown hearted tissues.

Lack of space does not permit us to give further descriptions of other common functional diseases as "Jonathan spot, apple scald, bitter-pit and water core." These disorders will be described in another publication.

Literature Cited

1. Ballard, W. S., Magness, J. R., and Hawkins, Lon. A. Internal browning of the Yellow Newtown apple. U. S. D. A. Bul. 1104. 1922.
2. Harding, Paul L. Respiration studies of Grimes under various controlled temperatures. Proc. Amer. Soc. Hort. Sci. 26. 1929.
3. Kidd, F., and West, C. Brown Heart—A functional disease of apples and pears. Dept. Sci. and Ind. Res., Food Inves. Bd. Spec. Rpt. 12. 1923.
4. Kidd, F., and West, C. Two types of storage internal breakdown in apples. Dept. Sci. and Indus. Res., Food Invest. Bd. Rpt. for 1927. 1928.
5. Overholser, E. L., Winkler, A. J., and Jacob, H. E. Factors influencing the development of internal browning of the Yellow Newtown apple. Cal. Agr. Exp. Sta., Bul. 370. 1923.
6. Plagge, H. H., and Maney, T. J. Soggy breakdown of apples and its control by storage temperature. Ia. Agr. Exp. Sta. Res. Bul. 115. 1928.

Respiration Studies of Grimes Apples Under Various Controlled Temperatures

By PAUL L. HARDING, *Iowa State College, Ames, Iowa.*

THE importance of storing apples immediately after picking has been demonstrated by the evidence accumulated by practically all storage investigators, and has been particularly emphasized by the work of Plagge and Maney (13) on the relationship of breakdown to the delay of fruit before entering storage. Just what physiological factor or factors are responsible for this condition is a question demanding much investigation. A picture of the respiratory activity going on within the tissue of the apple should give an indication of the rate at which the apple is living. At high temperatures the peak of respiration is reached within a very short time. On the other hand, apples immediately subjected to storage respire at a very much lower and more constant rate. Holding fruit in the orchard or warehouse for several days or even weeks before it enters storage must result in a disturbance within the apple, when it is thus transferred from a condition of high activity to one in which minimum of change takes place. About 60 hours are necessary for fruit at 50 degrees F. to reach a temperature of 30 degrees F. upon being transferred to the latter temperature. This lowering of temperature likewise affects the respiratory activity, decreasing the evolution of carbon dioxide from 13 or more milligrams per kilogram hour to 3 milligrams.

Quantitative measurement of carbon dioxide under these extreme conditions is easily determined. However, just how these changes affect the apple is a more difficult question to answer. We do know that soggy-breakdown results from delayed storage and the percentage is much greater at 30 degrees F. than at 36 degrees F. We also know that when apples are delayed at higher temperatures before entering storage, they are entering at a time when they are respiring at a very high rate.

Morse (12) measured the amount of carbon dioxide given off from apples stored at 32, 50, and 68 degrees F. His work specifically showed that the lower temperatures retard respiratory activity and thus prolong the life of the fruit.

Extensive work by Bigelow, Gore and Howard (1), and Gore (5) showed that the rate of respiration increases with the rise of temperature according to the Van't Hoff law.

Hill (7) studied the behavior of fruits and seeds under aerobic and anaerobic conditions. He pointed out injury due to insufficient oxygen and also possible injury due to the accumulation of carbon dioxide with the use of fruit wrappers. Magness and Burroughs (10) showed that apples, held at storage temperatures of 32 and 36 degrees F. respire at a very constant rate throughout the storage season. Burroughs (2) studied the respiratory activity of apples through the ripening period and the effect of alternating temperatures, wounding and coating with neutral mineral oil, and their effect on the subsequent respiration rate at 68.5°F.

Freezing the tissue reduces the production of carbon dioxide. Thus, Carrick (3) found that a lowering in temperature from 0 degrees to —8 degrees C. reduced the carbon dioxide evolution 90 times. He also found (4) that apples frozen for a few hours, increased their respiration at 0 degrees C. as much as 85 per cent. Some stimulatory affect was noticeable a month later.

Recent investigations by Kidd and West (8) (9) have shown a wide variation in respiratory activity of single apples taken from the same sample. Recognizing this variation of single apples due to differences of maturity and because of the high experimental error resulting from the use of small samples, Maney, Harding and Plagge (11) have described a large pickle bottle respiration chamber which was used very successfully in the following investigation.

The procedure and apparatus used for the determination of carbon dioxide as a measure of respiration was exactly that described by Harding, Maney and Plagge (6).

Experimental Work

Grimes Golden apples for these investigations were obtained from the Apple Grove Orchard, Mitchellville, Iowa. Within 12 hours from the time of picking all the fruits were graded, packed, transported to Ames, weighed, placed in the large respiration chambers and subjected to the desired temperature.

Respiration studies commenced three weeks previous to the time when Grimes were picked for commercial purposes. Analyses made on three different samples of Grimes picked at periods one week apart determined the respiration rate accompanying the development of the fruit and gave a more complete story of respiration.

These pre-commercially picked apples were placed under aspiration at 50 degrees F. for 50 to 60 hours before the determinations were commenced.

TABLE I—Rate of Respiration on Grimes Fruit from Early Pickings. Storage Temperature 50°F.

Date	No. of Apples	Wt. of Fruit in Grams	Mgr. CO_2 per Klg. Hr.
Lot 1			
Sept. 9	72	8791	9.59
Sept. 10	72	8791	9.08
Lot 2			
Sept. 16	70	8672	10.19
Sept. 17	70	8672	10.23
Lot 3			
Sept. 21	70	8959	12.29
Sept. 22	70	8959	12.08
Commercial Picking			
Lot 4			
Sept. 26	64	8846	14.38
Sept. 27	64	8846	14.08

The data in Table I show that there is a gradual increase in the production of carbon dioxide with the development of the fruit.

Pressure tests to determine the maturity, were made, but the common commercial practices governed the date of the commercial picking, which started a few days previous to September 25, when the fruit for this investigation was obtained. With the exception of the one jar of apples held at 60 degrees F. by means of a water bath, the storage temperatures selected for the respiration studies were 50, 36, and 30 degrees F. One lot was placed, immediately, in each of the four temperatures: 30, 36, 50, and 60 degrees F. Two lots were held at 50 degrees F. for three weeks and then one of them was placed in cold storage at 30 degrees F. and the other at 36 degrees F. Respiration determinations were made on all six lots of apples at weekly intervals throughout their storage season.

TABLE II—TREATMENTS TO WHICH THE SIX LOTS OF APPLES OF THE COMMERCIAL PICKING WERE SUBJECTED

Jar No.	Deg. Temp. in F.	Treatment	No. of Apples	Wt. of Fruit in Grams
1	60	Immediate storage, water bath control of temperature	60	7850
2	50	Immediate storage, cold storage	64	8846
3	36	Immediate storage, cold storage	65	8756
4	36	3 weeks delayed at 50°F. before storage at 36°F.	68	8860
5	30	Immediate storage, cold storage	70	8659
6	30	3 weeks delayed at 50°F. before storage at 30°F.	65	8608

It will be noted in Fig. 1, that the respiratory rate of apples placed at 60 degrees F. followed a curve similar to that of the fruit at 50 degrees F. However, the maximum respiration rate of apples was reached at 60 degrees F. nearly two weeks earlier or about three weeks from the time of storage, as compared with four or five weeks at 50 degrees F. The amount of carbon dioxide evolved was, therefore, more a matter of the stage of development than of temperature. In other words, the amount of CO_2 given off must be considered in the light of the stage of development.

When fruit is held in the orchard, packing shed or warehouse, for days or weeks before being placed under storage temperatures, it is transferred at a time of high respiratory activity, to a temperature which in two and a half days cuts the rate of respiration to a minimum. Maximum soggy breakdown was observed by Plagge (19) when apples were delayed at 50 Degrees F. for five weeks, and then transferred to 30 degrees F. This breakdown was 60 per cent greater than that obtained with transfer to 36 degrees F.

Under these conditions, it can be noted in Fig. 1 that this transfer came at the peak of respiration. It is significant to note (see Fig. 1) that when Grimes were transferred during the period of their highest

respiratory activity after two to five weeks delay at 50 F., to 30 F. or 36 degrees F., soggy breakdown resulted; but when they were transferred later, or during a period of lower respiration, after six to twelve weeks delay, no soggy breakdown was observed. When apples were retained throughout storage at 50 degrees F., which is more nearly the common storage temperature, no soggy breakdown developed. Thus, it is evident that soggy breakdown developed when the transfer occurred during high respiratory activity, and did not develop when the transfer was made during lower respiratory activity.

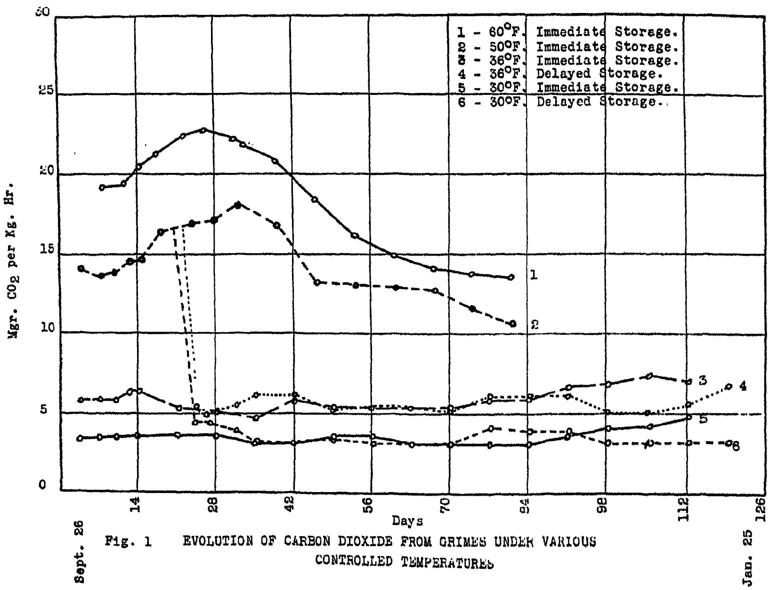


Fig. 1 EVOLUTION OF CARBON DIOXIDE FROM GRIMES UNDER VARIOUS CONTROLLED TEMPERATURES

The respiration rate of Grimes stored immediately at 30 degrees F. and at 36 degrees F. was more constant than that of the fruit which was delayed at 50 degrees F. for three weeks before being placed at the respective lower temperatures. As the storage season advanced, there was a gradual increase in the respiration rate in the apples placed in storage temperatures of 30 degrees or 36 degrees F. In the delayed storage fruit, there was an abrupt, although slight, rise in the rate of respiration some 70 days after picking. This increased rate continued for about three weeks. It was shortly after this abrupt increase in respiration that breakdown was first observed within the respiration chambers.

On January 25, after the apples had been in storage about four months, the fruit in the respiration jars was examined for breakdown, with the results shown in Table III.

Other collateral storage lots, l. c. (14) showed the following percentages of soggy breakdown: 3 weeks delayed storage at 50 degrees F. before storage at 30 degrees F., 60.3 per cent; 3 weeks delayed at 50 degrees F. before storage at 36 degrees F., 8.7 per cent.

TABLE III—CONDITION OF FRUIT IN THE RESPIRATION CHAMBERS AT THE END OF THE STORAGE SEASON FOR GRIMES.

Jar No.	Deg. Temp. in F.	Treatment	Condition of the Fruit
1	60	Immediate storage, water bath control of temperature.	Respiration determinations extended until the fruit had spoiled.
2	50	Immediate storage, cold storage.	Respiration determinations extended until the fruit had spoiled.
3	36	Immediate storage, cold storage.	Fruit sound.
4	36	3 weeks delayed at 50°F. before storage at 36°F.	28% breakdown.
5	30	Immediate storage, cold storage.	Fruit sound
6	30	3 weeks delayed at 50°F. before storage at 30°F.	82% breakdown.

SUMMARY

1. Respiration determinations were made on Grimes Golden apples at weekly intervals throughout the storage season. The fruit was held under the following controlled temperatures: 60, 50, 36, and 30 degrees F.

2. The rate of respiration increased with the development and maturity of the fruit under a uniform temperature. At the higher temperatures the maturity or stage of development affected the respiration rate.

3. It required about 60 hours for fruit at 50 degrees F. to reach 30 degrees F. upon being transferred to the latter temperature.

4. Fruit picked and held at higher temperatures soon reached a very high rate of respiration. When transferred to lower temperatures there resulted a disturbance within the fruit's tissue, upon being removed from a condition of high activity to a condition of retarded activity.

5. Soggy breakdown developed when Grimes at 50 degrees F. were transferred to a temperature of 30 degrees or 36 degrees F., providing the transfer came during the period of high respiratory activity, otherwise no breakdown developed.

6. The maximum percentage of soggy breakdown developed when Grimes, at their peak of respiration at 50 degrees F., were transferred to 30 degrees F.

LITERATURE CITED

1. BIGELOW, W. D., GORE, H. C., and HOWARD, B. J. Studies on apples. U. S. D. A., Bur. of Chem. Bul. 94. 1905.
2. BURROUGHS, A. M. Studies in apple storage. In Storage Investigations, 1921–22, The Marble Laboratory, Inc., 101–137., Canton, Pa. 1923.

3. Carrick, D. B. The respiration of apples at low non-freezing temperatures and while frozen. Proc. Amer. Soc. Hort. Sci. 1926.

4. Carrick, D. B. The effect of freezing on the respiration of apples. Cornell Agr. Exp. Sta. Mem. 110. 1928.

5. Gore, H. C. Studies on fruit respiration. U. S. D. A., Bur. of Chem., Bul. 142. 1911.

6. Harding, P. L., Maney, T. J., and Plagge, H. H. Apparatus for the determination of carbon dioxide in the respiration of apples. Science, 70: 125. 1929.

7. Hill, George R. Jr. Respiration of fruits and growing plant tissues in certain gases, with reference to ventilation and fruit storage. Cornell Agr. Exp. Sta. Bul. 330. 1913.

8. Kidd, Franklin and West, Cyril. The storage life of apples in relation to respiratory activity and chemical composition. Report Food Investigation Board, pp. 37–57, 1925–1926.

9. Kidd, Franklin and West, Cyril. Fruit and vegetables, Report Food Investigation Board, Section B, pp. 23–27. 1927.

10. Magness, J. R., and Burroughs, A. M. Studies in apple storage. In Storage Investigations, 1921–22, The Marble Laboratory, Inc., 17–98. Canton, Pa. 1923.

11. Maney, T. J., Harding, P. L., and Plagge, H. H. A new type of respiration chamber. Science, 70, p. 44. 1929.

12. Morse, Fred W. The respiration of apples and its relation to their keeping. N. H. Agr. Exp. Sta., Bul. 135. 1908.

13. Plagge, H. H., and Maney, T. J. Soggy breakdown of apples and its control by storage temperatures. Ia. Agr. Exp. Sta., Res. Bul. 115. 1928.

14. Plagge, H. H. Proc. Amer. Soc. Hort. Sci. 1929.

The Texture and Ripening of Bartlett Pears as Influenced by the Root Stock

By F. W. Allen, *University of California, Davis, Calif.*

THE French pear (*P. communis*) and the Japanese pear (*P. serotinia*) are both used in California as rootstocks for the Bartlett variety. In connection with pear maturity studies during the past few years it has been observed in the Lake County district that the fruit produced on these two stocks differs noticeably in color and that growers recognize a difference in time of ripening. It is customary to pick the fruit from the trees on French stock before harvesting that from the trees on Japanese stock. This seemed a somewhat questionable procedure since from casual observation fruit from the latter appeared more mature, usually showing a decided yellowish-green color while that on the French trees still appeared a decided green. Fruit from the former was frequently not harvested until several weeks after the beginning of the commercial picking season for the pears on French stock, and even when allowed to become decidedly yellowish before harvesting, possessed good shipping and keeping quality.

Comparative tests of the firmness of these two types of fruit with the pressure tester[1] showed that fruit grown on French stock, which appeared greener, possessed a decidedly softer flesh. This greener appearing fruit also tended to drop badly if allowed to remain on the trees until the fruit grown on Japanese stock was usually picked.

In view of these observations and the general commercial practice of growers in this district, it was decided to secure more definite information as to the influences of the Japanese rootstock on the firmness and general ripening of Bartlett pears. Was this difference one peculiar to this district, and noticeable on account of the usual high color of the fruit in this section, or did the same difference exist in other pear districts of the state? To answer this question it was planned to secure fruit from certain orchards in different localities where the same grower had trees growing on both French and Japanese rootstocks. From these orchards samples of each type of fruit were to be picked and tested for firmness. Where possible, early, medium, and late pickings were to be made from each orchard.

Inasmuch as the French rootstock was used practically exclusively until some 15 years ago, when the Japanese stock suddenly became popular on account of being more resistant to blight, it was somewhat difficult to find orchards containing trees of the same relative age on each of the two types of rootstocks. A number of fairly satisfactory orchards, however, were found, and in one instance an orchard planted in the Suisun district in 1918 had half of the trees propagated on French root and half on Japanese root. These trees are reported as having been planted on the same day. This naturally

[1]For description of the fruit pressure tester and method of making the tests see Calif. Exp. Sta. Bul. 470. "Maturity Standards for Harvesting Bartlett pears for Eastern shipment."

was an ideal orchard for a comparative test on any possible influence of the rootstock on the fruit produced.

Three pickings of pears were made from selected trees during the 1929 season with the following results:

TABLE I—FIRMNESS OF BARTLETT PEARS ON FRENCH AND JAPANESE ROOTSTOCKS

Date Picked	Average Firmness (20 Tests) in Pounds		Average Difference in Pounds
	French Stock	Japanese Stock	
July 15	29.7	32.0	2.3
July 24	24.8	26.0	1.2
August 3	21.2	23.3	2.1
	Seasonal average difference		1.9

Although the fruit from trees growing on the French and Japanese rootstocks in this orchard was practically identical in color, it did show at each picking a consistent and what is deemed a significant difference in firmness. Each of the samples picked on the different dates were held under top temperatures of refrigerator cars (approximately 50° F.) for 11 days and were then ripened under temperatures of 70° to 80° F. As was anticipated, the early picked samples softened quickly and were soon discarded as unsalable. No difference in keeping quality was noticed. In the second picking, the fruit from the Japanese stock ripened in five days and remained marketable three additional days; that from the French stock ripened in four days and was marketable three days. Fruit from the Japanese stock picked August 3 ripened in five days and remained good four days while the corresponding sample from French stock ripened in four days and was discarded as too soft for sale after one day.

Tests similar to the above were made in 27 orchards in seven rather widely scattered districts as follows:

(1) The Sacramento River section. The early district of the Sacramento Valley, with relatively high temperatures during the day and moderate to cool temperatures at night, relatively high humidity, rather heavy, deep soil, and an abundance of water for irrigation. (2) Monticello. An interior valley section, little water for irrigation, low humidity, and rather high temperature. (3) Lake and Mendocino counties. Valley sections with moderate temperature and humidity conditions, fruit grown largely without irrigation. (4) Placer county. Sierra Nevada foothill section, altitude 1500 to 2500 feet, soil rather shallow, limited irrigation facilities. (5) Eldorado County. Conditions similar to district 4 but season slightly later. (6) Suisun Valley. A coastal valley district bordering on Suisun Bay, cool temperatures with high humidity. (7) Folsom. A small district of Sacramento county, soil shallow, irrigation water somewhat limited, temperatures high, and humidity low.

Averaging the firmness of all the pickings secured from the different districts, Table II gives the average difference in firmness of the fruit on French and Japanese rootstock.

These data show that the difference in firmness is much more marked in some districts than in others, this difference being greatest

in Lake and Mendocino counties where first observed. The average difference for the seven districts is the same as found in the Suisun orchard in Table I. Though there are some indications that temperature and humidity conditions influence the effect of the stock upon the fruit, the results secured the past season are not conclusive in this respect.

TABLE II—FIRMNESS OF BARTLETT PEARS ON FRENCH AND JAPANESE ROOTSTOCK

Location	Number Orchards	Average Pressures in Pounds		Average Difference in Pounds
		Japanese Stock	French Stock	
Sacramento River	7	25.5	24.3	1.2
Monticello	2	24.6	21.6	3.0
Lake & Mendocino counties	8	22.6	17.9	4.7
Placer County	5	23.7	22.7	1.0
Eldorado County	2	18.4	17.8	0.6
Suisun	2	25.8	24.4	1.4
Folsom	1	20.5	19.3	1.2
Total	27	Average difference		1.89

From the above 27 orchards a total of 71 individual pickings were secured. Of these pickings, only 19 per cent failed to show the fruit from the Japanese stock to be firmer than that from the French. While, therefore, subsequent investigations may change the results slightly, the data of the past season show that in all districts the Japanese root does apparently influence the texture of the fruit.

In this connection mention should be made of the condition known as black-end or hard-end of pears which is very prevalent in California orchards where the trees are on the Japanese rootstock. These terms were doubtless adopted from the appearance and condition of the fruit around the calyx end. The trouble seems clearly to be associated with the rootstock. All samples of fruit for the above tests were selected as being free from any indication of the condition known as hard-end. Moreover, hard-end pears are usually of normal texture at the point of greatest transverse diameter. It is scarcely possible, therefore, that this condition is responsible for the differences found in texture. On the other hand, the greater firmness of the fruit from the Japanese stock may indicate the susceptibility of fruit grown on this stock to such trouble. Little difference was noted the past season in the color of the fruit from the two rootstocks.

Although fruit from trees on Japanese roots was firmer, and generally believed of better keeping quality, the time required for ripening and the length of time remaining marketable after ripening during the past season, was not on the whole greater than with fruit grown on the French root. Perhaps most of the Bartlett pear orchards in those districts of California where the fruit possesses the best keeping quality are on the Japanese rootstock. However, study of the detailed data secured the past season seems to indicate that general climatic conditions and the time of ripening are of as great, if not greater, importance to keeping quality than is the rootstock. Very firm texture is at least of no great advantage as is indicated by the fact that none of the fall and winter varieties of pears grown in California possesses nearly as firm flesh as does the Bartlett.

The Use of Modern Refrigeration for Experimental and Teaching Work in Horticulture

By A. F. YEAGER, *North Dakota Agricultural College, Fargo, N. D.*

TEACHERS of small fruit courses have always been handicapped by the fact that such fruits are perishable and hence could not be shown to classes to illustrate varietal differences and to acquaint the students with the standard sorts. Such students as may not have grown these fruits nor visited the experimental plots in the summer have had but a hazy conception of the subject. The same situation exists as regards flower courses which deal primarily with outdoor garden varieties. Even the teacher of vegetable courses finds individuals who have never seen an eggplant or a ground cherry and have never noted the differentiation between the blossoms of the squash.

Experiment Station workers, especially those in the North, have found it difficult to take as detailed notes on fruit and plant characteristics during the ripening season as they would have liked because of limited time. We believe this deficiency can be largely supplied by zero temperature storage of such materials.

At the North Dakota Agricultural College this summer a locker was rented in a local creamery where a temperature of −4 degrees Farenheit was maintained. In this locker fresh berries, plums, tomato vines, garden and greenhouse flowers, and perishable vegetables were placed when in proper condition. When these were removed in December they were, for the most part, in perfect condition so far as appearance was concerned. There were a few exceptions. Wandering Jew, for instance, shed its leaves. Gooseberries had a white appearance instead of the normal translucent color; some leaves looked rather dark but most of the material had the appearance of being fresh from the field. Students who examined them were much interested in seeing and handling things new to them.

There is no doubt but that a below-zero storage room in our Horticultural buildings would add much to the efficiency and interest of our teaching. As an example of the possible application to experimental work, we are this year examining the fruits of several hundred gooseberry and raspberry seedlings to check up on the variations in fruit characteristics which could not be done at harvest time. It would seem that the freezing method should also be useful in preserving disease specimens or for showing growth characteristics, blossom characteristics, and so on, of agronomic and botanical material.

The commercial freezing of small fruits such as strawberries and raspberries, which suggested this study, is now an assured success. This study has indicated such possibilities in the vegetable field. The appearance of frozen yellow sweet corn was particularly impressive so much so that it was taken home and cooked. The resulting corn on the cob was excellent and, in the opinion of the writer, fully equal to corn bought at the average market in summer time. The appearance, texture and flavor were all very much like the freshly picked product. Since corn could be stored in this way for less than 10 cents per dozen, there may be commercial possibilities in supplying corn on the cob for the Christmas dinner, as well as providing scientific and instructional material for institutions.

The Influence of Top on Root as Determined by Root Respiration of Young Fruit Trees

By G. H. Harris, *University of British Columbia, Vancouver, Canada.*

IN a previous paper by the writer (2), it was pointed out that certain tree roots had no rest period and that given favourable conditions, root growth took place the year round. Even if the top was in the resting stage or dormant, new root growth, especially in length, took place rapidly.

The following work was undertaken in part to determine, by measuring root respiration, how closely the activities of root and top were related, and also to devise an apparatus suitable for the continuous measurement of tree root respiration over long periods.

Apparatus and Methods

One-year-old trees (2-year roots) were grown in sealed specially constructed galvanized iron containers. These containers having a capacity of 60 litres, were painted inside with asphalt. Hoagland's nutrient solution was used as the culture medium (40 litres) for the tree. Twenty-five containers were set up in three wooden frames in a greenhouse. The following trees were used namely,—apricot on apricot root, apricot on myrobalan root, Bing cherry on mazzard root, Delicious apple on Delicious root, Bartlett pear on French root, Bartlett pear on Japanese root and Hardy pear on Quince root. Before the trees were set in the containers, all branches from the stem and all small fibrous roots from the root were removed.

The respiration of the roots was measured by the CO_2 produced. In order to displace the CO_2, and also to aerate the nutrient solution, a current of CO_2—free air was passed continuously through the nutrient solution in the containers into Milligan absorbing bottles containing KOH. The CO_2 absorbed by the KOH was determined by titration after the method of Blasdale (1).

To maintain the temperature of the culture solution approximately constant, the containers were packed in sphagnum moss. Frequent watering of the moss maintained the temperature in the containers around 15 degrees C. The solutions were kept approximately up to the original concentration, care being taken that none of the nutrients became excessively depleted. A close check was kept on the NO_3 ion and from time to time tests for other ions were made. Checks were made also on the percentage composition of the atmosphere inside the containers. Since percentage ran about 2 per cent. CO_2 and 18 per cent. O_2 quite consistently, there was no accumulation of CO_2. Blanks were run to determine whether the CO_2 originating from any other cause besides root respiration was significant. From this source a range of 0.03 to 0.07 grams CO_2 was recorded per week as opposed to from 1.0 to 7.0 grams per week given off by the tree roots. The accompanying diagram illustrates the set-up used in the experiment. The apparatus was set up April 3, 1927 and operated continuously for 18 months.

During the season 1927, the apricot on apricot trees, Bing on mazzard, Pear on quince, and Pear on Japanese made excellent

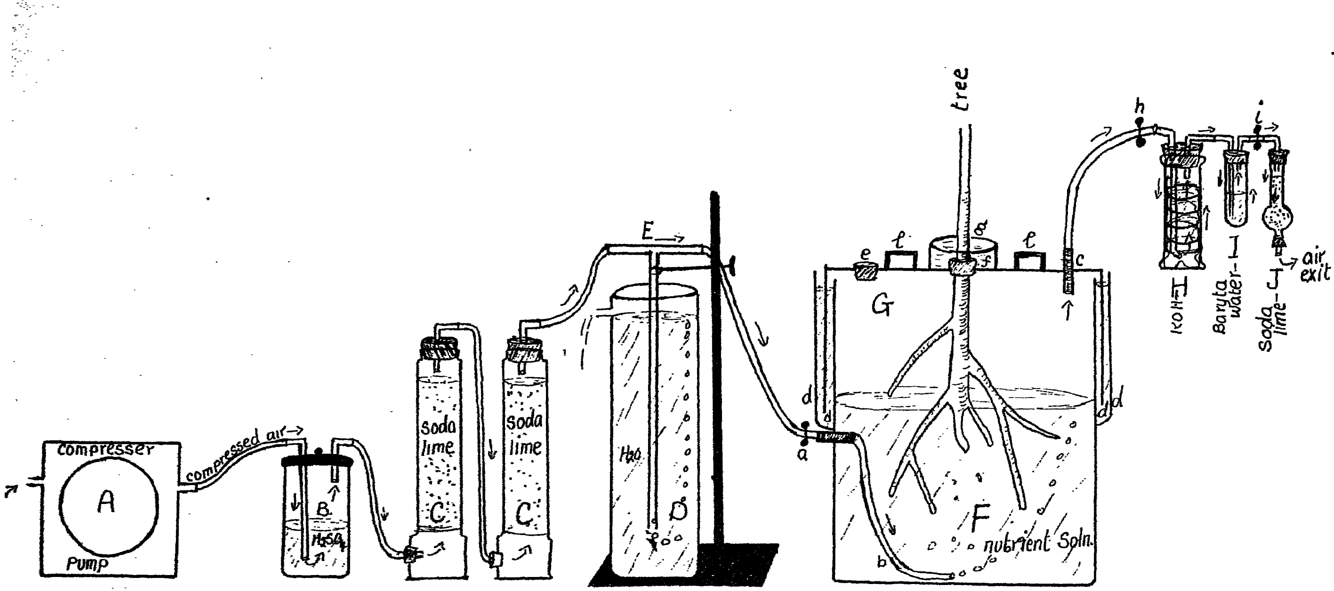


FIG. 1.—E, D: device to maintain a constant pressure of air entering the container. F: container fitted with double collar (d) into which fitted the lid G. (g) is another collar around the cork (f) through which the tree passed. The tree was sealed in the cork with grafting wax and the collars (d) and (g) filled with water. (e) is a stoppered opening to replace solution lost in transpiration. (1) are handles to raise the lid. H is Milligan absorbing bottle. I is an indicator and trap in case the KOH in the absorbing bottles became saturated before the bottles were changed. J is a soda lime tube to prevent CO_2 from the outside air entering the trap I. (a), (h), (i) are stop cocks; the rate of passing air through the system was regulated at (i).

growth, comparable to that of trees of the same age in the field. These trees were considered as normal trees, Group I.

The apricot on myrobalan, apple on apple, and pear on French, during the early part of the season did not do well, owing to various treatments which will not be discussed here. However, when given favourable treatment similar to Group I, normal growth took place but the trees had been weakened. These trees were considered as weak trees, Group II.

In the majority of trees of both groups, new shoots sprang from the upper portion of the stem. In the pear on quince and one of the pear on Japanese trees, however, the shoots appeared uniformly distributed on the stem from the upper to the basal portion.

Increase in diameter of the original stem at three fixed points, namely at the upper, middle, and basal portions was measured throughout the experiment. The diameter of the roots was not measured as it was imperative that the roots be disturbed as little as possible. The time of diameter increase in the base of the stem was taken as an indication of the time of increase in diameter of the root stub. Stem thickening appeared to take place first in the upper portion and lastly in the basal portion and end in the same order. These observations appear in accord with Knight (4) and Hatton and Amos (3). With the pear on quince and the one pear tree on Japanese, however, stem thickening appeared to start simultaneously at the upper, middle and basal portions, proceed uniformly the whole length of the stem and end simultaneously. These trees later were considered a sub-group by themselves, Group Ib, the remaining trees of Group I becoming Ia.

New root growth usually preceded shoot growth and continued to a greater or lesser degree throughout the experiment. During the winter months, December, January, and February, with a number of the trees, when no apparent activity was taking place in the top, the greatest primary root growth in length took place. In the spring of 1928 several of the trees bloomed.

Relation of Certain Activities of the Tree to Root Respiration

Buds: The bursting of healthy vegetative buds markedly depressed root respiration, although it increased prior to their bursting. When blossom buds burst in 1928, there was an increase in root respiration prior to their bursting but no decrease took place at the time they burst. These phenomena lead to some interesting speculation but will be discussed elsewhere later.

Shoot Growth: In the normal trees, Group Ia, at a certain stage in new shoot growth when the leaf area was increasing relatively fast, root respiration gradually increased to a maximum (July) which was either coincident with or a short time before or after shoot growth in length ceased. After this point, root respiration either remained fairly constant or had a slight tendency to drop until around September, when a second maximum, usually larger than the first, was attained.

In the pear on quince and the one pear on Japanese, Group Ib, root respiration reached a maximum in June, although shoot elongation did not cease until late July. After this relatively low June maximum was reached, a fairly constant level was maintained throughout the growing season.

In the weak trees, Group II, when normal growth occurred, two maximums appeared in the root respiration curve. The first maximum was either coincident with or before but not after shoot elongation ceased. In this case, however, before the second maximum was attained, a relatively large and distinct drop took place.

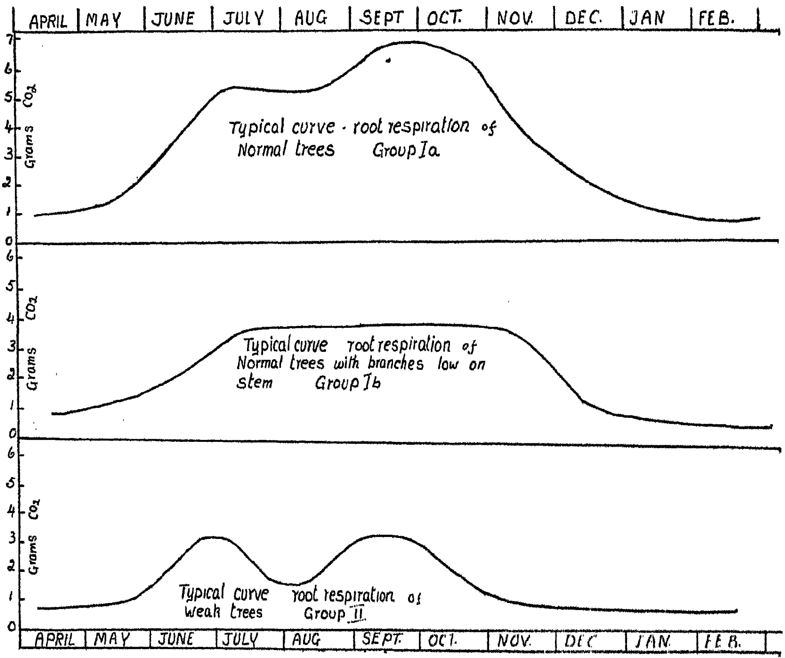


FIG. 2.

Increase in Diameter of the Stem: In the normal trees, Group I, after the first maximum (July) was reached and no further increase, or a slight depression in root respiration, took place, increase in diameter of the stem was going on in some cases slightly faster and in others at about the same rate as before the first maximum. In the weak trees, Group II, after the first maximum was reached and a pronounced depression in root respiration took place, increase in diameter of the stem was taking place relatively rapidly compared to before the first maximum. In this group, very little diameter increase was made while shoot elongation was taking place.

Diameter Increase of Root (stub): In the normal trees, Group Ia, when the second (September) maximum in root respiration took

place, diameter growth at the base of the stem was taking place fairly rapidly and presumably was doing so in the root, but had ceased in the upper and middle portions of the stem. In the pear on quince Group Ib, there was no second maximum in root respiration around September and as has been mentioned, the basal portion of the stem ceased thickening at approximately the same time as the upper and middle portions.

In the weak trees, Group II, when the second maximum in root respiration took place, diameter growth at the base of the stem was taking place fairly rapidly as in Group Ia, and had ceased in the upper and middle portions. The connection, then, between diameter increase of stem and root and root respiration seems clear.

The picture then presented is: in the weak trees, Group II, whenever normal growth appeared, root respiration showed a well defined maximum about the time shoot elongation ceased. This was followed by a distinct depression, while increase of the stem was taking place relatively rapidly. Then a well defined maximum took place as the base of the stem and presumably the root continued to increase at the time the upper portion of the stem was either growing relatively slowly or had ceased to grow. With the trees of Group II, the sequence was clearly defined and although results were less definite in the case of trees of Group I, all the evidence points to a similar behaviour with the members of that group as well.

Primary Root Growth in Length: New root growth usually started before buds burst. Root respiration was low at this time, even though in some cases this new root growth was rapid. During December, January, and February, when all other apparent growth had ceased but this new root growth in length was relatively rapid, root respiration was low. It may be significant that, particularly within a species, more dense fibrous branched roots appeared to have higher respiratory activity than more open and sparsely branched new roots, irrespective of the total weight of the new roots produced.

Discussion

With the measurement of root respiration as a criterion, it would appear that any activity of the top markedly influences the activity of the root. As the leaf surface and photosynthesis increase, there soon comes a time in normal trees when the leaves are producing enough respiratory material to supply all growth processes simultaneously in the top and also in the roots. These growth processes are in competition with each other and if the supply of respiratory material is not great, as in weak trees, all may be used for shoot growth in length. Not until a more plentiful supply is elaborated or shoot growth ceases will diameter growth of the stem take place. The evidence suggests that it takes a certain concentration of this respirable material to initiate diameter growth. When diameter growth does occur, the amounts of respiratory material required are greater than for shoot growth, because when shoot growth took place in the weak trees some did reach the roots but when diameter growth occurred, comparatively little reached the

roots. Even in the normal trees, if increase in diameter were not a greater drain on supplies than shoot elongation, a steady increase in root respiration after shoot elongation ceased instead of a level or a decrease until the September maximum would be expected. The September maximum in root respiration clearly indicates that at this time the root is receiving a relatively large supply of respiratory materials.

The low respiratory activity of the rapid new primary root growth suggests that at certain periods, although there may not be sufficient active respiratory material in the root for diameter increase, there may be for length growth. The rapid winter primary root growth then would appear not to be a very exhaustive process to the tree and these new unsuberized roots form a ready passage for water or mineral nutrients into the tree if any such deficit should occur.

Acknowledgment

Grateful acknowledgment is given to Dr. J. P. Bennett, University of California, for his helpful suggestions while the work was being carried on at Berkeley.

Literature Cited

1. Blasdale, W. C. Principles of quantitative analysis. Van Nostrand & Co. 1924.
2. Harris, G. H. The activity of apple and filbert roots. Proc. Amer. Soc. Hort. Sci. 414. 1926.
3. Hatton, R. G., and J. Amos. Experiments upon the removal of laterial growth on young apple trees in summer. The effect on stem and root development. Jour. Pom. and Hort. Sci. 6:67. 1927.
4. Knight, R. C. The relation in the apple between the development of young shoots and the thickening of older stems. Jour. Pom. and Hort. Sci. 6:72. 1927.

Old Roads and New Trails in Horticulture

(Presidential Address)

By V. R. GARDNER, *Michigan State College, East Lansing, Mich.*

IN 1717 John Lawrence prefaced his "Art of Gardening" with the statement: "Gardening is of late Years become the general Delight and Entertainment of the Nobility and Gentry." That sentence and others appearing in his own writings and those of his contemporaries indicate that gardening (the word horticulture apparently had not yet been coined) was either more or less of a menial occupation for the laborer or an avocation for the leisure class and that in either case it was for the amateur. A half century later Philip Miller wrote: "The improvements which have been made in the art of Gardening, within fifty years past, are very great. Our markets being better supplied with all sorts of esculent plants, through the whole year, than those of any other country; and these in their several seasons are afforded at so cheap rates, that they are become a great part of the food of the poor; to which we may in part attribute the abatement of those violent scorbutick disorders, which formerly raged so much in this country." Here is evidence that gardening had become, in part at least, commercialized and that there was beginning to be some appreciation, if not a real understanding, of the value of horticultural products from the standpoint of health.

The trend toward the commercial instead of the amateur, toward the making of horticulture more and more of a business or an industry and perhaps something of a science and less and less of an art has been steady for a century and a half and apparently is more pronounced today than at any former time. How much of the progress that has been made in this direction is due to the so-called professional horticulturists and to efforts of those who have attempted to apply the results and the methods of science to horticultural problems, it is impossible to say. That much of the more recent progress has been coincident with the development of the Agricultural Experimental Stations is certain. Our own organization has played an important part in stimulating research in the horticultural field, in developing and maintaining *esprit de corps* among research workers, and in establishing standards for measuring their achievements. Indeed, as a group and as an organization we may take a just pride in what has been accomplished. Simply to enumerate and catalog these achievements would be a considerable task. There have been some attempts along this line and consequently another is not required at this time. Merchants, however, sometimes take stock and business men make surveys, not so much to find out what they are, as to discover what they are not, carrying or doing. The same principle may be applied to our own field. It is with this object in view that what follows has been written.

Fads and Fancies

Today as horticulturists, we smile tolerantly at the silk-worm mulberry craze of the early part of the last century, at the one-time fad for Dutch bulbs, at the fashion that decreed the camellia as the aristocrat among flowers or that assigned the Angouleme grown as a dwarf to a similar place among fruits. We look rather condescendingly on espalier training of peach trees and we find it hard to take seriously all that Thomas Rivers believed and taught regarding root pruning. One is sometimes tempted to wonder what, a generation from now, will be the opinion about our present-day furore about hydrogen-ions, carbohydrates, growth inhibitors and nicely-calculated probable errors. Lest there be a misinterpretation of what is intended, let me hasten to state that no criticism is meant of our present fund of information on these matters. The regret is that we do not have more, so that we may see things in better perspective. In the meantime, however, there is great need of more attention being devoted to other things. In our enthusiasm for that which may be of secondary importance, though perhaps intensely interesting, we are carried away and more or less ignore that which is really vital to the industry.

Changing Trends in Horticultural Production

Were I to state that the entire output of the research workers in the field of horticulture for the past 50 years has done less to change and direct the trends of horticultural production than what has been done during the last half of that period by the research agencies in an entirely different field of applied science, I would probably be challenged. Yet I believe such to be the case. Why is it that, relatively, people eat less meat and grain today and more fruits and vegetables than a generation, or even a decade, ago? Certainly not because of what horticultural research workers have done. Nor has it been a matter of accident or chance. In a very important sense the commercial horticulture of today is what it is because of the findings of research workers in the field of human and animal nutrition. Perhaps this is to be expected and as it should be; but I cannot help but believe that if some of our best horticultural thought were turned to this and related matters, horticulture, which we are supposed to be serving, would profit still more. There must be some contribution that we can make, if nothing more than reading the handwriting on the wall and seeing that it is not carbohydrates and calories that are to demand the premium in the food markets of the future, but rather cellulose and colloidally held water, sweetened, flavored, and colored to taste. Horticultural crops of the future must be bred and raised accordingly, leaving to the agronomist and general farmer the task of providing the body with its fuel. The horticulturist's job is to provide the roughage, flavor, spice, and sweetening and in the most enticing form.

In the fruit industry the most striking development of the past generation has been the rise of the orange and grapefruit. To what and to whom has this been due? To the sales agent and the organ-

ization behind him in part—and also to the results of research agencies that have found out the dietary value of those fruits. It has not been horticultural research agencies. Research work of the right kind by, or directed by, horticultural agencies could do as much, perhaps more, for the apple. In the production of field crops the country has largely emerged from the horse-power and entered the gasoline-engine age. Many farmers do not realize this but they are, nevertheless, reaping the profits or taking the consequences. Just what is the rôle of the gas engine and tractor in horticulture? To assume that the answer of the Kansas wheat farmer to this question either is or is not the answer for the Florida celery grower or the Wenatchee orchardist is to beg the question. Yet, who among us is giving serious thought to these and related questions? Here are some real problems for the horticultural research worker.

The development of the canning industry is pointed to as something which theoretically has made possible placing a horticultural product on every table every meal every day in the year. Our part in the development of that industry has been a minor one. Today the small mechanical refrigeration unit promises changes that will remake the canning industry and that affects horticulture directly. To what extent are the interests of horticulture and horticulturists being protected, enlarged and developed by research work in this readjustment that is just now starting?

Economic or Horticultural Leadership in the Merchandizing Field

For the past ten years there has been a great hue and cry over over-production, low prices, faulty distribution, and the ills of the merchandising system in general. Many claim that the marketing problem is the all-important horticultural problem, as it is the all-important agricultural problem. We may not all agree to that extreme statement of the case, but, neither can it be brushed aside as temporary, superficial or inconsequential. Recently some attention has been given to a study of these problems, but most of these studies have been made by economists identified with Departments of Economics. Studies by horticulturists are strangely lacking. There is no intent to discredit the work of the trained economists, but very few of them have the horticultural background to enable them to interpret and apply their findings. What is needed is the combined efforts of economist and horticulturist, to effect a real solution of the problem; or, if there can't be combined effort, the horticulturist must enter the field alone. To sidestep these economic questions, to attempt to shift responsibility for their solution, is to adopt the habit of the ostrich of putting its head in the sand when danger is near. The industry has a right to expect a real leadership and real leadership can come only after the most thorough study of the situation. The best ability is none too good for this extremely difficult problem. The only question is as to whether it is good enough.

Challenging Accepted Doctrines

The ambition to gain recognition by making a clever contribution to a subject that is much in the public eye and much discussed is laudable. At least it cannot be seriously criticized, because it is through these contributions that a well rounded picture is finally obtained. Much, however, as we need the chipping and polishing of the well placed stones of some of our substantial structures, we need still more the remodeling and rebuilding of a number of our antiquated structures; or perhaps some of them should be torn down and rebuilt from the ground up. We are taking a lot of things for granted and solemnly teaching them in classroom and extension school, that need only a sharp challenge to be shown as false. Who can discuss the problem of filler trees in any but an academic way? Where is the evidence to show that close planting is or is not better than wide spacing? What can a fruit grower afford to pay for the use of bees in his orchard at blossoming time? What are the most practicable methods of increasing the size of fruit—not, what can be done to increase size—but, what are the most practicable methods of doing it? How many Station bulletins, in a very paternal way, tell the reader to secure good seed, the best seed?—And how many of the writers of those bulletins can get right down to brass tacks and tell him where and how? How many professional horticulturists that have a hand in shaping the extension policies in their own states can with absolute certainty name, in the order of their relative importance, the factors which determine the success or limit the profits in the apple or onion or cantaloupe industries of their state? Yet, can a sound extension policy be formed without that information, and can that information be obtained without some extremely careful investigation (not just inquiry, but real research) and how much research of that type is actually under way?

Orchard Management on Undeveloped Field

Take the closely related problem of Orchard Management. I refer here not to cultural practices, as such, but to their interrelations and to their relations to such questions as changes in distribution, in consumer demand, in labor and material costs, etc. What do we have today in the way of a fund of reliable information—of scientific information? Can we tell anybody whether his spraying costs too much or his cultivation is too expensive for the results achieved? Perhaps instead of a study of the fruiting habits of his trees the grower needs a stop watch held on his pruning and spraying operations. Within recent years there has grown up in the field of commerce and industry a science of business management. A few of the best institutions are offering well organized courses along this line. I hardly need to tell you that such information in the Horticultural field is practically non-existent. Yet there is every reason to believe that this field is as fertile, as important, as susceptible of scientific analysis and interpretation as the field of plant nutrition. It affords a challenge to the keenest intellects and the soundest judgment in our ranks.

Physiology and Other Sciences

The past one or two decades have witnessed notable contributions in the field of plant physiology and in their applications to the solution of horticultural problems. Indeed, it might almost be said that physiological and horticultural research have progressed jointly, that they have gone hand in hand. This is well. It is a matter of considerable satisfaction to both groups that some of the best physiologists of today are likewise rated among our best horticulturists and that a few of our leading horticulturists are more or less at home with the physiologists. Similarly, some of our ranks have entered the field of chemistry, especially biological chemistry, and are bringing to bear the new acquisitions of that science on horticultural problems. However, plant physiology alone will not explain the incompatibility of certain graft unions; nor will the biological chemist tell us all that we need to know about soil acidity and crop residues. It seems to me that in vegetable gardening in particular, any real understanding of the fundamental principles governing crop adaptations, crop rotations, companion cropping, weed control, etc., must come from ecological studies. The question may well be raised as to whether or not just as much is not to be gained by the same kind of close contact with the fields of physical chemistry, plant ecology, plant anatomy, and bacteriology.

The reference that has just been made to the need of more horticultural research work using physical and perhaps general inorganic chemistry as a tool leads to the observation that most of the new developments in the field of insecticides and fungicides have been the contributions of chemists, physicists, and entomologists employed by commercial agencies rather than of horticulturists connected with our state and federal research organizations. All the help we can get from these other agencies is to be welcomed; but it may be questioned if the horticultural research organizations are doing their full duty in the matter when they limit their activity largely to testing what is offered for sale. While we worry about the proper technique of laboratory determinations, the rabbits and mice are girdling growers' trees and we are far from the best solution of his problem. Here is a field for our workers in colloids. A certain amount of creative work can reasonably be expected of the horticulturist.

Plant Materials

A generation ago an extensive, intimate acquaintance with plant materials was regarded as a part of the necessary equipment of the horticulturist. Indeed, the knowledge of species, varieties, and strains was both a science and an art. Today how many of our professional horticulturists are recognized as authorities on even a single group of fruits or vegetables or ornamentals? Here and there we find such authorities, but they are all too few. The excuse is made that a knowledge of practices and processes and principles is more important. Perhaps so, but the suggestion is ventured that if investigators possessed a better knowledge of plant materials with which they are working, they might have less difficulty in explaining

behavior; certain alleged responses to treatment might not be classed as responses, and there might be less necessity of recourse to probable error. Statistical constants have their place in horticultural research, but sometimes one is tempted to regard some of them as rather poor crutches on which to lean when a more careful study of the material itself would give a far more reliable view of the situation. In our quest for greater refinement in analytical methods, better technique, thinner sections and higher magnification (all of which is very laudable) we should not lose sight of the fact that, by and large, the horticulture of today differs from that of a century or a generation ago, more in materials than it does in practices.

Careful reflection will show that most of our present horticultural maps are chiefly determined by varieties and most of them are subject to radical changes when the proper new variety comes along. Perhaps we do not need the acquaintance with varieties that T. T. Lyon had, but we need, as never before, to recognize as though by instinct whether our standard material is at its best and whether new material has possibilities for some particular use. In Michigan the annual commercial pack of canned Keiffer pears is approaching the million dollar mark and bids fair to go to several times that figure. Both canners and consumer would like a product with a little less prominent grit cells. The Michigan Station has been devoting considerable time and money to a study of the factors associated with grit cell formation and to cultural practices that might influence it. We have acquired some interesting information, but have found no way materially to reduce the number or size of grit cells; yet with comparatively little effort we have found a new Kieffer-like pear (one that even the experienced systematic pomologist would be likely to mistake for the Kieffer) that has much less prominent grit cells and whose canned product is almost as smooth as that of the Bartlett. Doubtless the same general principle that applies here is of much wider application.

Something is needed to bridge the gap between the geneticists on one hand and seedsmen and nurserymen on the other. It will not dc to say that this is a commercial and not a scientific field. This field is not even charted; say nothing of its being well enough known foı commercial interests to enter it with any degree of confidence. Tc study this question carefully, to determine its possibilities and limi tations, to differentiate between the relatively fertile and the relativel barren areas, is as much the province of the professional horticulturis as is the subject of flower bud formation and in the long run wil yield results much further reaching. He who expects to make mucl headway, however, must be an expert plantsman as well as a gooc geneticist.

Amateur and Ornamental Horticulture

The last two or three decades have witnessed a marked develop ment of commercial horticulture. Gradually, and probably more c less unconsciously, research work has come to bear more or les exclusively on the problems of the commercial interests. This readily understood when it is realized that time and funds are limite

and the commercial interests are usually organized in such a way that they can bring their problems to the attention of the research agencies much more readily than can the amateurs. On the whole, however, amateur horticulture is hardly second in importance to the commercial side, a statement that will be concurred in when attention is called to the fact that ornamentals belong to horticulture. Our research programs have more or less ingored the amateur gardener and yet his problems are as many and as interesting as those of the commercial grower. Research may make some of the amateur's plants commercial. I would not want to put the rock garden ahead of the grape industry; but I wish to call attention to the fact that there is a science as well as an art to rock gardening and to most of us that science is as foreign as Sanskrit or Astronomy.

Observation Still A Method of Investigation

A generation or two ago most of our new information was gained by observation or by comparatively simple field trial. More recently we have been turning to the laboratory method, to the use of the most accurate and precise of yardsticks, and to the invention of many mechanical aids and devices. These all have their places; and estimate is seldom or never as good as a measurement. However, there are plant laboratories where the plants would feel, if they had the ability to feel, that they were out of place because so completely overawed and dominated by apparatus. I do not wish to underestimate the value or importance of good equipment, but it is worth mentioning that observation still has its place as a method of procedure in horticultural research. Darwin's ability to form and then test hypotheses, his synthetic reasoning, would have availed little had he not been an almost uncannily keen observer. It is neither more nor less scientific than the laboratory method. The laboratory technician still invokes the aid of experimental error in explaining discrepencies and inconsistencies. There is a real danger that we shall come to shift all the responsibility of interpretation to mechanical umpires. We must not forget that much of our biological progress has been made by men who have interpreted their observations. Injudiciously chosen samples may be as misleading as impressions. With all our refinement of method, few of us will have as accurate a comprehension of our field as did Patrick Barry or Prosper J. Berckmans or Peter Henderson.

Originality

There is need for more originality in our research efforts. Some bold spirit discovers something—or thinks he does. Forthwith a host of followers crowd in and check and then re-check what has been done. Sometimes, so great is the hue and cry in chase of the new idea that all effort in finding other new ideas is virtually abandoned for a time. This, too, has its place, for the original discovery may be extended, new applications may be found, or perhaps the whole thing may be found to be no new discovery at all—just a false alarm that needs correcting. Probably most of us are not fitted by nature

for creative thinking, for originating new ideas. All we can do is to develop and apply the old ones. There is certainly need for much effort along these latter lines and such effort should be commended and encouraged. Paths must be traced and tramped and worn until they become arterial highways that all may travel; but, likewise, new trails must be blazed.

What does it matter if some of them do end blindly? There will never be any short cuts made by always following the old road. And let no one think that there are no new short cuts to be found, no new trails to be blazed. There are men appearing on the program of this meeting, men in this room, who have had the courage and the enterprise to step out of line and try to find something really new, and some of them have succeeded or are succeeding. A flash of imagination now and then will do wonders for the advancement of our science,—(or, if it is not yet a science, for the industry which it serves).

Perspective

Last, but not least, there is need of more attention to the fitness, the relative importance, of things in planning our research programs. In a large way the science of horticulture cannot develop far ahead of the industry; nor is the industry likely to forge far ahead of the science. Both should, as a matter of fact must, be developed together. Horticultural industry is advancing on a wide front. Horticultural science is showing a tendency to press forward rapidly here and there. Figuratively, we are thrusting out a few sharp salients without enough attention to the position of the main line. The horticultural industry as a whole has a right to look to its professional men for leadership. If this challenge is to be accepted in the full sense, it means a broadening, an extension, of our activities and some consolidation of gains already made. There will be no less attention to detail but there should be more attention to perspective. There will be, metaphorically, no less use of the microscope, but a greater use of the telescope.

There is a real need of a new score card for our horticultural programs and our horticultural men. The past ten years has witnessed a very gratifying and wholly proper demand for research. But there is danger of running to a one-sided standard, to the idea that anything that can be comprehended by the layman is not research and is worth scant attention, that something that is comprehended by only a few is *per se* of great importance. There is danger that we may overlook the fact that clear thinking still remains rarer than technical accomplishment and that wide field experience, coupled with technical knowledge and clear thinking may solve abstruse problems in simple terms and be of immense value to the art and industry we serve.

Let us, then avoid the single standard of accomplishment and excellence. Let us recognize that horticulture is a wide field, with a mobile, steadily, though irregularly advancing front; that it demands efforts of various kinds and men of various types; that vivid imagination, keen intellect and sound judgment are no less important than technical ability; and let us formulate our programs and bestow our laurels in recognition of this diversity.

Relation of Oil Spray to Production of Apples in Washington

By F. L. Overley and Anthony Spuler, *State College of Washington, Pullman, Wash.*

A PROGRESS report was given a year ago on the effect of dormant and delayed dormant application of oil sprays on apple trees. Experimental work was continued this year to study the relation of different sprays and other factors to fruit bud injury and set of fruit and the relationship of various emulsifiers used in the oil sprays and of oil concentration to plant injury. Studies were made also of the toxicity of oil sprays to plants as compared with lime sulfur. A check was made with the previous season's results in reference to temperature and time of application of the sprays. The effects of summer oils on fruit drop following lime sulfur in dormant and pink sprays were studied as well as the effect of summer oil sprays on the size and growth of fruit.

In the 1929 field tests of dormant sprays, Jonathan trees 18 to 20 years old were used. At various intervals from March 6 to April 15 two trees were sprayed with the following spray materials.

1. Check, no dormant spray of any kind was applied.
2. 4% permanent emulsion No. 5 oil-unsulfonated residue 70, viscosity 100.
3. 4% quick breaking emulsion oil-unsulfonated residue 70, viscosity 100.
4. 4% semi-quick breaking emulsion oil-unsulfonated residue 70, viscosity 100.
5. 3% quick breaking emulsion oil-unsulfonated residue 70, viscosity 100.
6. 4% commercial oil quick breaking emulsion unsulfonated residue 70, viscosity 117.
7. 5 ° Baume lime sulfur
8. 3 ° Baume lime sulfur
9. 4% quick breaking emulsion, Oronite Tech. Oil, unsulfonated residue 98, viscosity 120.

These tests were made to determine: (1) whether oils of high refinement are safer under all conditions than the unrefined oils commonly used in dormant sprays and (2) whether a quick breaking emulsion produces more injury than a permanent one.

In 1928 oils ranging in sulfonation test from 50 to 70 per cent were used with results that were identical from the standpoint of injury. In 1929, oils with sulfonation tests of 70 to 98 were used to determine if the summer oils could be used more safely than a moderately refined dormant oil.

Field tests in the past have indicated that quick breaking emulsions are more likely to produce injury than permanent emulsions. DeOng, Knight and Chamberlain* have shown that quick breaking emulsions

*Hilgardia Vol. 2, No. 9. Jan. 1927.

deposit relative large amounts of oil on the plants and that but little oil is contained in the run off. Quick breaking emulsions in these tests were prepared by using small amounts of calcium caseinate (3 oz. to 2 gal. of oil) as the emulsifying agent. The semi-quick breaking oils were prepared by using larger amounts of calcium caseinate (6 oz. to 2 gal. oil) while the permanent emulsions were prepared by using an oil soluble soap (cresoap 1-9) thus forming a miscible oil.

TABLE I—FRUIT BUD INJURY FROM DIFFERENT SPRAYS AT VARIOUS TIME OF APPLICATION

Spray Material	Date of Application	Total Buds Examined	Per cent injury
1	——	2790	1.68
2	Mar. 6	1264	.87
	Mar. 18	1218	.41
	Mar. 27	1399	1.00
	Mar. 31	1124	.62
	Apr. 3	1737	2.01
	Apr. 6	1116	2.32
	Apr. 10	1326	1.12
	Apr. 15	1345	2.30
3	Mar. 6	1463	.68
	Mar. 18	1156	.35
	Mar. 27	1357	1.32
	Mar. 31	1406	1.63
	Apr. 3	1247	6.17
	Apr. 6	1410	5.17
	Apr. 10	946	6.65
	Apr. 15	1299	1.92
4	Mar. 6	1540	1.68
	Mar. 18	1380	2.10
	Mar. 27	1499	.46
	Mar. 31	751	3.06
	Apr. 3	1035	8.50
5	Mar. 6	1045	1.91
	Mar. 18	1357	1.25
	Mar. 27	1321	.98
	Mar. 31	1374	1.60
	Apr. 3	1035	2.12
6	Mar. 6	1244	1.52
	Mar. 18	1366	.87
	Mar. 27	1255	1.51
	Mar. 31	1426	1.54
	Apr. 3	1512	5.48
7	Mar. 6	1455	1.92
	Mar. 18	1289	2.17
	Mar. 27	1499	.95
	Mar. 31	1299	1.46
	Apr. 3	1386	1.94
8	Mar. 6	1384	1.30
	Mar. 18	1101	.82
	Mar. 27	1196	1.67
	Mar. 31	1714	2.45
	Apr. 3	1354	2.21
	Apr. 6	1083	.37
	Apr. 10	1166	.77
	Apr. 15	1581	1.70
9	Apr. 10	1196	1.25
	Apr. 15	1327	2.78

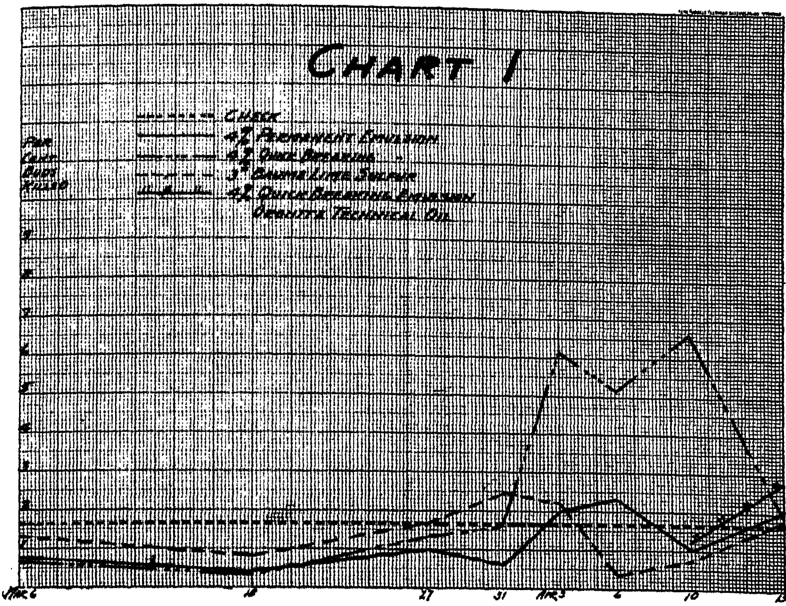


CHART I
CHECK
4% QUICK BREAKING
MAR 6
18
27
31
APR 3
6
10
15

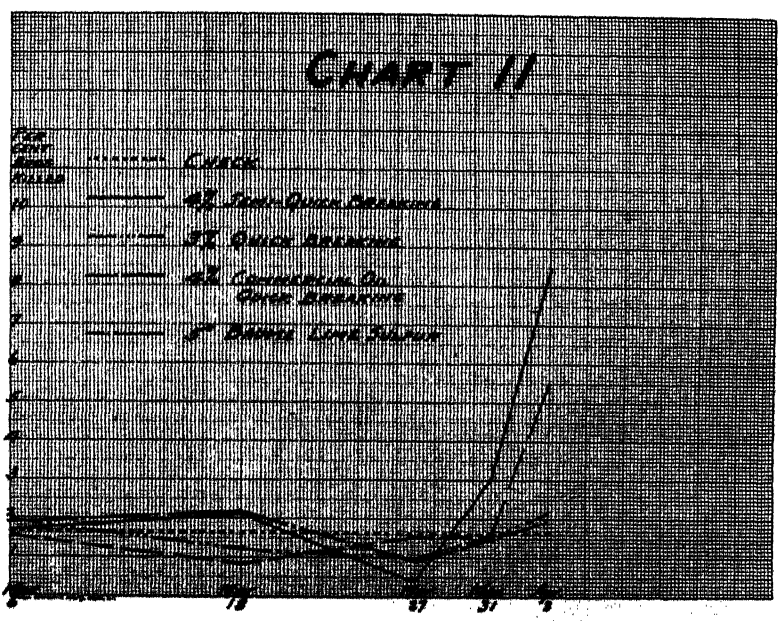


CHART II
CHECK
5% QUICK BREAKING
27
31

An average of 25 gal. of spray liquid per tree was applied, thru a spray gun, at 300 lbs. pressure at the nozzle. Tables I and II give the dates of application of sprays and the fruit bud injury as determined at blossom time.

Charts I and II show in graphic form bud injury from the use of quick breaking and semi-quick breaking oils in the sprays as compared with check lime sulfur and permanent emulsion.

All Jonathan trees in the orchard where this work was carried on were very heavily loaded. The per cent of bud injury was too small to affect the crop.

Table II gives the per cent of fruit set and the average number of apples produced including both thinnings and harvested fruit.

TABLE II—PER CENT OF FRUIT SET AND TOTAL CROP AFTER TREATMENTS 1 AND 3

Spray Treatment	Date of Application	Total Buds Examined	Fruit Set Per cent	Apples Thinned per Tree	Harvested per Tree	Total per Tree
Check	None	2790	15.2			
No. 3	Mar. 6	1463	17.63	1974	3199	5173
	Mar. 18	1156	19.11	1609	3321	4930
	Mar. 27	1357	17.09	2342	2972	5314
	Mar. 31	1406	12.51	2632	2642	5274
	Apr. 3	1247	11.86	1542	1852	3394
	Apr. 6	1410	12.55	1674	2672	4346
	Apr. 10	946	12.26	2115	2585	4700
	Apr. 15	1299	15.54	1970	3026	4996

The Jonathan bud injury in 1929 was very similar to that in 1928 but the 1928 crop was so much lighter that the result was noticeable in the crop at harvest time. No comparisons were made with Winesap and other varieties in the experimental plots in 1929, but results from 1928 and from grower's orchards show that Winesaps are very much more susceptible to oil injury than Jonathans. In 1928 Jonathans showed bud injury to the extent of 15–20 per cent while Staymans and Winesaps the same year showed bud injury as high as 30–75 per cent. Oil sprays applied after the middle of February with low temperatures, even sub-zero, have not shown any injury to fruit buds up to the time the first green starts to show in the bud.

Table III shows the minimum and maximum temperatures from March 1 to May 1st.

Temperatures appear to be a factor in so far as it affects the development of the bud during the critical period. If the mean temperature is low during the opening of the buds they make very slow growth and are subject to injury when sprayed with oil at that time.

The members of the Western oil spray project comprising the experimental stations of Idaho, Montana, Oregon, Washington, and British Columbia and the United States Department of Agriculture, in annual conference at Spokane December 12–13, 1929 made the following suggestions in the use of dormant oil sprays on apples

and pears for the Pacific Northwest. These suggestions were based on data accumulated from experimental work during the past three years.

TABLE III.—MAXIMUM AND MINIMUM TEMPERATURES IN THE ORCHARD FROM FEB. 26 TO APR. 22

Date	Min.	Max.	Date	Min.	Max.	Date	Min.	Max.
Feb. 26	24	46	16	27	56	4	25	48
27	33	50	17	25	59	5	29	54
28	38	51	18	27	64	6	27	51
Mar. 1	28	53	19	27	65	7	32	53
2	45	58	20	43	63	8	29	51
3	44	58	21	40	51	9	23	54
4	46	62	22	32	49	10	29	49
5	32	57	23	35	57	11	34	52
6	27	54	24	31	56	12	26	56
7	28	58	25	30	51	13	36	54
8	25	53	26	35	55	14	45	60
9	38	53	27	38	59	15	29	53
10	36	55	28	39	58	16	35	54
11	37	54	29	26	49	17	32	61
12	26	54	30	31	59	18	27	66
13	28	56	31	29	54	19	33	64
14	25	58	Apr. 1	28	57	20	44	65
15	27	54	2	45	61	21	31	65
			3	36	57	22	34	72

1. Dormant oil sprays should be applied in the spring before the bud scales separate and before the buds show green. Injury may result if sprays are applied during the critical period (delayed dormant) of bud development. This period occurs between the time the buds first show green and the cluster bud stage.

2. There is no evidence that low temperatures following sprays applied in the spring during the dormant stage result in injury.

3. Oils of relatively low sulfonation test (50–70) can be used safely.

4. Stable emulsions have proven safer than quick breaking emulsions.

Relation of Combination Sprays to Spray Residue Problems in Washington

By F. L. OVERLEY, *State College of Washington, Pullman, Wash.*

LEAD arsenate has been used as a standard spray for codling moth control for many years. As the codling moth became more numerous in a fruit district, more arsenical sprays were needed for its control.

Some feeble efforts were made to remove the arsenical residue by wiping, but in general, apples from the Pacific Northwest were placed on the markets previous to 1926 with no attempt to remove the spray residue. Late in the season, 1925, the necessity for cleaning fruit was emphasized by the action of the authorities of England. They showed that some American apples were carrying over .1 grains of arsenate (As_2O_3) per pound of fruit. This amount being in excess of the tolerance they had previously adopted (.01 grains of (As_2O_3) per pound of fruit) an embargo on American apples was threatened.

Investigations were started in 1926 by the Washington Agricultural Experiment Station along three different lines.

1. Removing the arsenate from the fruit by wiping.
2. The use of solvents in residue removal.
3. The use of substitutes for lead arsenate in the spray schedule.

During the fruit season of 1926 wiping was resorted to almost entirely by the industry. Rag and brush wipers and cotton flannel gloves were largely used. However, the experiences of the season and the results of thousands of analyses indicated that fruit sprayed with more than three cover sprays of lead arsenate could not be cleaned by wiping to the .01 tolerance required for foreign shipment, although with but few exceptions it was all cleaned to the .025 or domestic tolerance in force at that time.

At the same time many tests were made using different solvents, both alkali and acid, to dissolve and remove the arsenate. Storage tests were run of all the treatments. The general results proved very satisfactory and the manufacturers started the development and manufacturing of washing equipment.

During the second season, fall 1927, many of the larger packing plants installed washing machines of various types, from home made dipping tanks to conveyor type of machines. The season's results were highly satisfactory. The manufacturers continued to change and improve their machines. The following season found practically every packing plant, including both central and growers plants in the districts of heavy spray schedule, equipped to wash their fruit. However, it was found that some of the later varieties of apples when allowed to stand for several days after harvest, developed a wax which made the removal more difficult. The same was true with fruit sprayed with oils in the codling moth spray program. Tests were then carried on to determine the temperature for the wash solution and the acid solution necessary to clean the most difficult

fruit without injury. The results indicated that with a Hydrochloric acid concentration of 1 to 1½ per cent and temperature of the wash solution from 90 to 105 degrees F. all lots of fruit, except a few of the most difficult, could be cleaned to the present domestic tolerance of .017 and most of them to the .01 tolerance for foreign shipments. The industry quickly accepted the results and as the cool weather developed during the packing season now drawing to a close, many of the washing machines have been equipped with heaters. Four types of heaters are being used: Electric coils, Steam jets, Stove with direct circulation and Steam boiler with coils in tank. Further investigations are necessary with the different methods of heating because of the expense of operation. dilution of acids, labor, fire and danger hazards and short life of equipment due to high concentration of acid in wash solution, and more especially when the solution is heated. Hydrochloric acid is the leading solution for arsenate residue in use at the present time. However, new solutions are being tested with promising results and further tests will be made next season.

In the lower valleys of some of the fruit districts of Washington, it has been necessary for some time to spray from three to eight times with lead arsenate to control codling moth. With practically no rain from bloom period to harvest time there is a gradual accumulation of arsenical residue on the fruit. For the past four years, the Experiment Station has been carrying on numerous tests with different substitute spray materials for lead arsenate for codling moth control. Most of the substitutes that have been tried have been discarded as of no value. Mineral oil and fish oils in combination with lead arsenate and nicotine sulfate in the spray program give much promise in codling moth control. With these spray combinations the spray residue is still a factor, but with present improved methods and equipment for cleaning the fruit, little trouble is expected providing the grower follows the recommendations suggested.

The members of the Western Cooperative Oil Spray Project in Annual Conference at Spokane, December 12 and 13 offer the following suggestions to growers of the Northwest who are planning on using combination sprays.

1. The number of applications of summer oils should not exceed three, and under most conditions not more than two are advisable.

2. The use of oils alone has not given control of the codling moth. Oils should be used only in combination with lead arsenate or nicotine sulfate.

3. Oils in combination with lead arsenate should be applied during the height of the egg-laying period of the first brood, but if sulfur sprays are applied after the dormant period, no oil should be used in the first brood sprays.

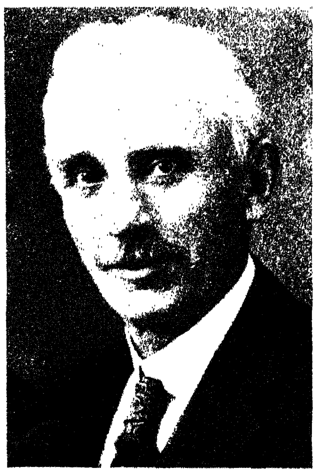
4. Because of the difficulty of removing spray residue, the oil-lead arsenate combination should not be used after July 25, but the oil-nicotine sulfate combination may be used after this date. (Lead-oil combination after this date may result in difficult removal of spray residue.)

5. Oils ranging in viscosity from 65–75 have proven most satisfactory, except that for Newtowns or other varieties susceptible to oil injury, the viscosity of the oil should not exceed 55.

6. Oils with a sulfonation test not less than 85 are satisfactory.

7. Caution: Oils in combination with lead arsenate should not be allowed to stand in pipes or spray tanks, but should be applied immediately after being mixed. Fruit sprayed with this combination after the spray has been allowed to stand in tanks or pipes for some time can be cleaned only with great difficulty. This spray mixture is also ineffective in control.

The spray residue situation, although serious at times has probably been a blessing in disguise to the Northwest. Today practically 100 per cent of the 40,000 or more cars of apples shipped out of Washington are wiped or washed. As a result the customer receives an apple cleaned of dust and dirt, free from spray residue and of a higher grade due to the improved methods of spraying as the result of the spray residue situation that developed in the fall of 1925.



ALVIN CASEY BEAL

Obituary

Alvin Casey Beal

The sudden death from cerebral hemorrhage on May 6, 1929, of Dr. Alvin C. Beal, Professor of Floriculture in Cornell University, Ithaca, New York, came as a great shock.

Born near Mt. Vernon, Illinois, November 30, 1872, he was reared on the farm of his parents who specialized in horticulture. He graduated from the University of Illinois with the degree of B.S. in 1897 and was foreman the next two years of the Horticultural Department of the Illinois Experiment Station. After a year's graduate work in Cornell University toward his master's degree, he returned to the University of Illinois and took charge of the horticultural greenhouses, growing vegetables, fruits, and flowers. He was for eight years instructor in Floriculture in the University of Illinois where he taught the courses in Plant Propagation, Greenhouse Construction and Management, and Floral Decoration.

In 1909 he came to Cornell for further study and received the degree of Ph.D. in 1911, when he was appointed Assistant Professor, and two years later Professor of Floriculture in the College of Agriculture. He was acting head of the Department of Floriculture and Ornamental Horticulture at the time of his death.

Dr. Beal was greatly interested in the historical aspects of his science, and was at the time of his death planning to make the results of his studies available in book form. Primarily a research worker, he devoted years to monographic studies of the sweet pea and gladiolus. He also made similar studies of the rose, iris, and peony, having been in charge of the test gardens, conducted at Ithaca in cooperation with the various floriculture societies. He was the author of a book on "The Gladiolus."

Dr. Beal was a life member of the Illinois State Horticultural Society, charter member of the Illinois State Florists' Association, serving as secretary in 1908, secretary of the American Gladiolus Society, chairman of the nomenclature committee for several years, and botanist of the S. A. F. and O. H. in 1912–1913. A Fellow of the A. A. A. S., he was also a member of the Society of Sigma Xi and of Pi Alpha Xi.

Professor Beal had a wide acquaintance and his services were much sought as a lecturer on floriculture subjects and as a judge of exhibitions. He was a valued and trusted associate and counsellor, his advice and leadership being careful and well considered. He was a loyal and conscientious worker, spending himself to the utmost endurance of his strength in every cause which he espoused.

Mrs. Ervilla B. Beal

Obituary

Charles Spencer Crandall

Few men have been so long and so closely identified with American horticulture as had Professor Crandall, who died at Hollywood, California, July 11, 1929. He served the University of Illinois for 27 years. Prior to that time he served the State of Colorado as Professor of Horticulture for 12 years and before that the State of Michigan in the Department of Horticulture, associated with Professor L. H. Bailey during a period of some four years.

Endowed by nature with ability and enthusiasm for his work, he was equipped for a life of distinguished service. His high ideals of education and research were influential in advancing the standards of scholarship, teaching, and original investigations in the Universities of three different state institutions. As a teacher, he had sympathetic understanding and appreciation of the problems of his students. These traits, combined with his ability as an instructor, gave him a personal contact with students that is treasured by those who were privileged to receive his instruction. To him, each student represented an opportunity to make an individual life more worthwhile.

At the Illinois Experiment Station Professor Crandall produced more than 45,000 apple seedlings and 8,000 peach seedlings. More than 50 of these crosses have been meritorious but so far none have been given general distribution.

As a student of science, the soil and the plant had a peculiar charm for him. The undeveloped possibilities in the field of pomology appealed to him deeply and he put into that service all his powers of intellect and industry. To experiment and give to the world the value of his accumulated knowledge, he regarded as a special privilege and as his life's duty. He thought, in a large way, along original lines and especially in the field of horticulture his activities were not simply for the present success, but for a fuller and richer future. His vision took in the days to come and his plans were for generations unborn.

Crandall's day's work commenced at seven and ended at six, with no thought of drudgery for the long hours spent in his outdoor or indoor laboratory or at his desk. Evening, too, usually found him in his modest, quiet home, pouring over scientific magazines or acquainting himself with the current events of the day. It was in this humble retreat that I so frequently sought his counsel and his inspiration.

A quarter of a century is not long in a man's life, but through this period of time I enjoyed the association of a rare character, my friend and co-worker. I treasure the memory of these evenings spent with him.

J. C. Blair

C. S. CRANDALL

H. D. HOOKER, Jr.

Obituary

Henry Daggett Hooker, Jr.

Dr. H. D. Hooker, Associate Professor of Horticulture at the University of Missouri was accidentally killed on October 26, 1929, at the age of 37 years.

He was born in Brooklyn, New York, in 1892. At the age of 20 he received the A.B. degree from Yale University. Enjoying a travelling fellowship from his Alma Mater, he spent the next year under Ludwig Jost, the well known teacher of plant physiology, at Strassburg, Germany. Upon his return from abroad he obtained his A.M. degree; and, while serving for two years as assistant in botany, he completed his training for the Ph.D. degree in plant physiology and physiological chemistry under Dr. L. B. Mendel in 1915. During the following three years, Dr. Hooker was instructor of Botany at Yale, which position terminated by his entrance into war service, first as Assistant Physiologist in gas defence organization of the U. S. Bureau of Mines, and later as Lieutenant in Chemical Warfare Service. In 1919 he was appointed Assistant Professor in Horticulture at the University of Missouri and made an Associate in 1920.

Dr. Hooker came from an old New England family, was of slender build, fair, and with prominent intellectual features. Putting to good advantage his ability and training, he concentrated his activities on plant physiological and biochemical investigations in the field of horticulture. His contributions on hardiness, nitrogen fertilization, fruit bud formation, carbohydrate metabolism and biennial bearing have brought him renown both in this country and abroad. Whatever he undertook was logically planned and well done.

Being scholarly predisposed by training and inclination, Dr. Hooker probably displayed his greatest efforts in reviewing and summarizing the contributions of other investigators in plant physiology and horticulture. He was a master in abstracting technical papers and translating their contents into plain, clear and pointed language. His several review articles and two books, prepared in collaboration with V. R. Gardner and F. C. Bradford, give full testimony of this ability. Hooker's premature death has been a great loss to Horticultural Science in America.

A. E. Murneek

Obituary

Feliks Kotowski

Dr. Feliks Kotowski, professor of Horticulture at the College of Agriculture, Warsaw, died on July 29, 1929, of blood-poisoning caused by a scratch of the lower lip.

Dr. Kotowski was born May 18, 1895, near Radom in central Poland. He received the degree of Doctor of Philosophy from the Jagellon University in Krakow in 1919.

Until 1922 he was assistant at the Horticultural Department of the State Scientific Institute at Pulawy. In January 1922 he was appointed Professor of Olericulture at the College of Agriculture, Warsaw and Director of the Institute of Olericulture and Vegetable Breeding at Skierniewice near Warsaw.

From July 1926 till September 1927 Professor Kotowski spent in America as a fellow of the International Education Board. During his sojourn in America he worked at the University of California.

Professor Kotowski was a man who combined a broad scientific education with great industry. During ten years of his scientific work he published some forty papers upon morphology, physiology, and breeding of vegetable plants. He was the author of a text-book of horticulture and several popular publications on different horticultural questions. He was also one of the leaders in organizing the olericulture experimental work in Poland.

The untimely death of Professor Kotowski has been a great loss to Polish horticultural science. His students have lost a bright guide and a real friend.

J. Golinska

FELIKS KOTOWSKI

FAN-CHI KUNG

Obituary

Fan-Chi Kung

Mr. Fan-Chi Kung was born on August 24, 1900 in Chengtu, Szechwan, China. Both of his parents died while he was still a mere child. He was brought up by his grandfather until 1914 when his grandfather died. After the death of the latter he was cared for by his first uncle.

In the fall of 1915 after a competitive examination he was sent by his provincial government to the Tsing Hua Middle School, Peking. In the spring of 1919, the most eventful year in China, he graduated from the Middle School and the next fall entered the High School which was then a part of the Tsing Hua College. He graduated from the Tsing Hua High School in the spring of 1923. During these eight years in Tsing Hua he was once President of his Class, once Manager of the College Annual and during the Student Movement of 1919 and the following years he was a member of the Executive Committee of the Tsing Hua Students' Association which was a mainstay of the Movement. He was a member of many clubs, social, scientific, and literary. He was once elected as Chairman of the Agricultural Club.

In the fall of 1923 he was sent to the United States to study. After a few months at Cornell University, he transferred to the Iowa State College and took up Pomology as his life's work. He graduated from the Horticulture Department at Iowa State College in the summer of 1926. He was elected to Gamma Sigma Delta and was awarded the Russel I. Klopp Prize. During his undergraduate days at Ames he held several offices in the local Chinese Students' Club. During his postgraduate days at Ames he was elected President of the local Cosmopolitan Club and Vice-Chairman of this district, and he also held office in the local Chinese Students' Club. He was Secretary of the United States Branch of the Agricultural Society of China and at the same time Secretary of the United States Branch of the Science Society of China.

After graduation he pursued graduate work in Plant Physiology at the University of Chicago for a year. He then went to California and investigated the fruit industry for about half a year. He was called back to Ames and was appointed as a graduate assistant in the Pomology Section of the Iowa Agricultural Experiment Station. He would have completed the work for his Ph.D. degree in June, 1930. On the evening of July 4, 1929, he was injured in an automobile accident and died the same night at the College Hospital. He was buried in the Iowa State College Cemetery on Sunday, July 7, 1929.

T. J. Manry

MEMBERSHIP ROLL FOR 1929

ABBOTT, C. E. . . . . University of Florida, Gainesville, Fla.
ADRIANCE, G. W. . . . . A. & M. College of Texas, College Station, Tex.
ALDERMAN, W. H. . . . . University Farm, St. Paul, Minn.
ALDRICH, W. W. . . . . University of Maryland, College Park, Md.
ALLEN, F. W. . . . . University Farm, Davis, Calif.
ANDERSON, L. C. . . . . Hudson, N. Y.
ANDERSON, O. G. . . . . Purdue University, Lafayette, Ind.
ANDERSON, W. C. . . . . University of Missouri, Columbia, Mo.
ANTHONY, R. D. . . . . Experiment Station, State College, Pa.
ASAMI, Y. . . . . Tokyo Imperial Univ., Komaba near Tokyo, Japan
AUCHTER, E. C. . . . . U. S. Dept. Agr., Washington, D. C.
AUSTIN, LLOYD . . . . 60 Bedford Ave., Placerville, Calif.

BABB, M. F. . . . . University of Maine, Orono, Me.
BAILEY, J. S. . . . . Agricultural College, Amherst, Mass.
BAILEY, L. H. . . . . Ithaca, N. Y.
BAIRD, W. P. . . . . Northern Great Plains Field Station, Mandan, N. D.
BAKER, C. E. . . . . Purdue University, Lafayette, Ind.
BARNETT, R. J. . . . . Agricultural College, Manhattan, Kans.
BARRON, LEONARD . . . . Garden City, N. Y.
BARSS, A. F. . . . . University of British Columbia, Vancouver, B. C.
BATCHELOR, L. D. . . . . University of California, Riverside, Calif.
BEACH, F. H. . . . . Ohio State University, Columbus, Ohio
BEATTIE, J. H. . . . . U. S. Dept. Agr., Washington, D. C.
BEATTIE, W. R. . . . . U. S. Dept. Agr., Washington, D. C.
BEAUMONT, J. H. . . . . College of Agriculture, Raleigh, N. C.
BENNETT, H. B. . . . . Rosebank, Ebley, Stroud, Gloustershire, England
BENNETT, J. P. . . . . University of California, Berkeley, Calif.
BINKLEY, A. M. . . . . Colo. Agricultural College, Ft. Collins, Colo.
BIOLETTI, F. T. . . . . University of California, Berkeley, Calif.
BLACKMON, G. H. . . . . University of Florida, Gainesville, Fla.
BLAIR, J. C. . . . . University of Illinois, Urbana, Ill.
BLAIR, W. S. . . . . Experiment Station, Kentville, Nova Scotia
BLAKE, M. A. . . . . Experiment Station, New Brunswick, N. J.
BOSWELL, V. R. . . . . Bureau Plant Industry, Washington, D. C.
BRADBURY, DOROTHY . . . . . . 1420 Polk St., Topeka, Kans.
BRADFORD, F. C. . . . . Michigan State College, East Lansing, Mich.
BREGGER, J. T. . . . . Washington State College, Pullman, Wash.
BRIERLEY, W. G. . . . . University Farm, St. Paul, Minn.
BRODRICK, F. W. . . . . Agricultural College, Winnipeg, Manitoba
BROWN, G. G. . . . . Oregon Agricultural Exp. Station, Hood River, Ore.
BROWN, H. D. . . . . Purdue University, Lafayette, Ind.
BROWN, W. S. . . . . Oregon Agricultural College, Corvallis, Ore.
BUCK, F. E. . . . . University of British Columbia, Vancouver, B. C.
BUNTING, T. G. . . . . Macdonald Col., Macdonald Col. P.O., Quebec, Can.
BURK, EARL F. . . . . University of Wisconsin, Madison, Wis.
BURKHOLDER, C. L. . . . . Purdue University, Lafayette, Ind.
BURRELL, A. B. . . . . Cornell University, Ithaca, N. Y.
BUSHNELL, JOHN . . . . Experiment Station, Wooster, Ohio

CALDWELL, J. S. . . . . U. S. Dept. Agr., Washington, D. C.
CAMERON, S. H. . . . . University of California, Berkeley, Calif.
CAMP, A. F. . . . . University of Florida, Gainesville, Fla.
CARRICK, D. B. . . . . Cornell University, Ithaca, N. Y.
CHADWICK, L. C. . . . . Ohio State University, Columbus, O.
CHANDLER, FREDERICK . . . . University of Maine, Orono, Me.
CHANDLER, W. H. . . . . University of California, Berkeley, Calif.
CHARLES, F. G. . . . . Ohio State University, Columbus, Ohio
CHITTENDEN, FRED F. . . . . . Royal Hort. Gardens, Wisley, Ripley, Surrey, England
CLAPP, RAYMOND K. . . . . . . 901 Postoffice Bldg., New Haven, Conn.
CLARK, J. H. . . . . Experiment Station, New Brunswick, N. J.

CLARK, JR., W. S. . . . . P. O. Box 167, State College, Pa.
CLOSE, C. P. . . . . U. S. Dept. Agr., Washington, D. C.
COCHRAN, G. W . . . . Oklahoma A. & M. College, Stillwater, Okla.
COIT, J. E . . . . 535 Prescott Street, Pasadena, Calif.
COLBY, A. S. . . . . University of Illinois, Urbana, Ill.
COLE, W. R. . . . . Agricultural College, Amherst, Mass.
COMIN, DONALD . . . . Experiment Station, Wooster, Ohio
CONDIT, I. J. . . . . University of California, Berkeley, Calif.
CONNORS, C. H. . . . . Experiment Station, New Brunswick, N. J.
COOPER, J. R. . . . . University of Arkansas, Fayetteville, Ark.
CORBETT, L. C . . . . U. S. Dept. Agr., Washington, D. C.
CRANE, H. L. . . . . U. S. Pecan Station, Albany, Ga.
CRIST, J. W. . . . . Agricultural College, East Lansing, Mich.
CULLINAN, F, P. . . . . Purdue University, Lafayette, Ind.
CUMMINGS, M. B . . . . University of Vermont, Burlington, Vt.
CUNNINGHAM, J. C. . . . . Iowa State College, Ames, Ia.
CURRENCE, T. M . . . . University Farm, St. Paul, Minn.

DALY, P. M. . . . . 263 Charlotte St., St. John, N. B.
DARROW, G. M. . . . . U. S. Dept. Agr., Washington, D. C.
DARROW, WM. H. . . . . Connecticut Agricultural College, Storrs, Conn.
DAVIS, HELEN I . . . . Wellesley College, Wellesley, Mass.
DAVIS, L. D. . . . . University Farm, Davis, Cal.
DAVIS, M. B . . . . Dominion Experimental Farm, Ottawa, Canada
DAY, L. H . . . . University Farm, Davis, Cal.
DEAN, M. L. . . . . State Department of Agriculture, Boise, Idaho
DEARING, CHARLES. . . . . Willard, N. C.
DEGMAN, E. S . . . . University of Maryland, College Park, Md.
DETJEN, L. R . . . . University of Delaware, Newark, Del.
DICKSON, G. H . . . . Vineland Station, Ontario, Canada
DIEHL, H. A . . . . Wenatchee, Wash.
DIKEMAN, R. C. . . . . National Farm School, Farm School, Pa.
DORNER, H. B. . . . . University of Illinois, Urbana, Ill.
DORSEY, M. J . . . . University of Illinois, Urbana, Ill.
DRAIN, B. D . . . . Agricultural College, Amherst, Mass.
DRINKARD, JR., A. W. . . . . . Experiment Station, Blacksburg, Va.
DUDLEY, F. H. . . . . 21 Parkwood Blvd., Poughkeepsie, N. Y.
DURUZ, W. P. . . . . Oregon State Agricultural College, Corvallis, Ore.
DUTTON, W. C. . . . . Michigan State College, East Lansing, Mich.
DYE, A. P. . . . . University of West Virginia, Morgantown, W. Va.

ECKERSON, SOPHIA H. . . . . . Boyce, Thompson Institute Yonkers, N. Y.
EDMOND, J. B. . . . . University of Maryland, College Park, Md.
EGUCHI, TSUNEO. . . . . Osaka Ag. Exp. Sta., Sakai-Shigai, Osaka fu, Japan
EMMERT, E. M . . . . University of Kentucky, Lexington, Ky.
EMSWELLER, S. L . . . . University Farm, Davis, Calif.
ERWIN, A. T . . . . Iowa State College, Ames, Ia.
EZELL, B. D . . . . Box 67, Wenatchee, Wash.

FAGAN, F. N . . . . Experiment Station, State College, Pa.
FAROUT, F. W. . . . . Missouri Fruit Station, Mountain Grove, Mo.
FELLERS, C. R. . . . . Agricultural College, Amherst, Mass.
FISHER, D. F. . . . . Wenatchee, Wash.
FITCH, C. L. . . . . Iowa State College, Ames, Iowa
FLEMING, HAROLD K . . . . . . National Farm School, Farm School, Pa.
FLEMING, W . . . . Experiment Station, Summerland, B. C.
FLETCHER, S. W . . . . Pennsylvania State College, State College, Pa.
FLOYD, W. L. . . . . University of Florida, Gainesville, Fla.
FRENCH, A. P . . . . Agricultural College, Amherst, Mass.
FRIEND, W. H. . . . . Box 295, Weslaco, Texas
FROST, H. B. . . . . Citrus Experiment Station, Riverside, Calif.
FUJIMURA, JIRO. . . . . College of Agriculture, Tsu, Mie, Japan
FURR, J. R. . . . . Cornell University, Ithaca, N. Y.

Gardner, F. E. . . . . University of Maryland, College Park, Md.
Gardner, J. S. . . . . University of Kentucky, Lexington, Ky.
Gardner, M. E. . . . . North Carolina State College, Raleigh, N. C.
Gardner, V. R. . . . . Michigan State College, East Lansing, Mich.
Geise, F. W. . . . . University of Maryland, College Park, Md.
Goldie, J. A. . . . . Vineland Station, Ontario, Canada
Gonzales, L. G. . . . . University of Philippines, Los Banos, Laguna, P. I.
Gossard, A. C. . . . . University of Wisconsin, Madison, Wis.
Gould, H. P. . . . . U. S. Dept. Agr., Washington, D. C.
Gourley, J. H. . . . . Experiment Station, Wooster, O.
Gray, G. F. . . . . Michigan State College, E. Lansing, Mich.
Graves, G. W. . . . . Fresno State College, Fresno, Calif.
Greene, L. . . . . Purdue University, Lafayette, Ind.
Griffiths, David. . . . . U. S. Dept. Agr., Washington, D. C.
Guengerich, H. W. . . . . . . Farm Bureau, Independence, Mo.

Haber, E. S. . . . . Iowa State College, Ames, Iowa
Haller, M. H. . . . . U. S. Dept. Agr., Washington, D. C.
Hanna, G. C. . . . . Route 1, Box 60, Rio Vista, Calif.
Hansen, N. E. . . . . Agricultural College, Brookings, S. D.
Hardenburg, E. V. . . . . . . Cornell University, Ithaca, N. Y.
Harding, Paul L. . . . . Iowa State College, Ames, Ia.
Hardy, Max B. . . . . Experiment Station, Pullman, Wash.
Harley, C. P. . . . . Box 907, Wenatchee, Wash.
Harrington, F. M. . . . . . . University of Montana, Bozeman, Mont.
Harris, G. H. . . . . Univ. of British Columbia, Vancouver, B. C.
Hartman, Henry. . . . . Oregon Agricultural College, Corvallis, Ore.
Harvey, E. M. . . . . Oregon Agricultural College, Corvallis, Ore.
Harvey, R. B. . . . . University Farm, St. Paul, Minn.
Hawthorn, Leslie R. . . . . Experiment Station, Geneva, N. Y.
Hedrick, U. P. . . . . Experiment Station, Geneva, N. Y.
Heinicke, A. J. . . . . Cornell University, Ithaca, N. Y.
Hendrickson, A. H. . . . . . University Farm, Davis, Calif.
Hendrickson, H. C. . . . . . Box 133, San Juan, Porto Rico
Hepler, J. R. . . . . Agricultural College, Durham, N. H.
Herrick, R. S. . . . . State House, Des Moines, Iowa
Higgins, J. E. . . . . P. O. Box 383, Balboa Heights, Canal Zone
Hildreth, A. C. . . . . Experiment Station, Orono, Me.
Hirano, Eiichi. . . . . Tottori Agricultural College, Tottori, Japan
Hodgson, R. W. . . . . University of California, Berkeley, Cal.
Hoffmann, G. P. . . . . Penny Farms, Green Cove Springs, Florida
Hoffman, I. C. . . . . Experiment Station, Wooster, Ohio
Hoffman, M. B. . . . . University of West Virginia, Morgantown, W. Va.
Hofmann, Fred W. . . . . . . Experiment Station, Blacksburg, Va.
Holland, C. S. . . . . Ohio State University, Columbus, Ohio
Hollister, S. P. . . . . Agricultural College, Storrs, Conn.
Holsinger, C. V. . . . . Iowa State College, Ames, Ia.
Hoppert, E. H. . . . . University of Nebraska, Lincoln, Neb.
Horn, Claud L. . . . . U. S. Dept. Agr. Exp. Station, St. Croix, V. I.
Horsfall, Frank. . . . . A. and M. College, Monticello, Ark.
Hoshino, Yuzo. . . . . The Hokkaido Imperial University, Sapporo, Japan
Howard, W. L. . . . . University Farm, Davis, Calif.
Howe, G. H. . . . . Experiment Station, Geneva, N. Y.
Howlett, F. S. . . . . Exp. Station, Wooster, O.
Huelsen, W. A. . . . . University of Illinois, Urbana, Ill.
Huffington, J. M. . . . . Pennsylvania State College, State College, Pa.
Hughes, E. C. . . . . University Farm, Davis, Calif.
Husmann, F. L. . . . . Second and Seminary Streets, Napa, Calif.
Husmann, G. C. . . . . U. S. Dept. Agr., Washington, D. C.
Hutchins, A. E. . . . . University Farm, St. Paul, Minn.

Isbell, C. L. . . . . Alabama Polytechnic Institute, Auburn, Ala.

JACOB, H. E. .... University Farm, Davis, Calif.
JOHNSON, T. C. .... Virginia Truck Experiment Station, Norfolk, Va.
JOHNSTON, S. M. .... Experiment Station, South Haven, Mich.
JONES, H. A. .... University Farm, Davis, Calif.

KEENE, P. L. .... Agricultural College, Brookings, S. D.
KELLEY, V. W. .... University of Illinois, Urbana, Ill.
KIMBALL, D. A. .... Agricultural College, Guelph, Ontario, Canada
KIMBROUGH, W. D. .... Alabama Polytechnic Institute, Auburn, Ala.
KINMAN, C. F. .... 409 Native Sons Bldg., Sacramento, Calif.
KNELMER, C. L. .... University of Wisconsin, Madison, Wis.
KNOTT, J. E. .... Cornell University, Ithaca, N. Y.
KNOWLTON, H. E. .... West Virginia University, Morgantown, W. Va.
KOLESNICOV, V. A. .... Kubansky, Ag. Institute Krasnodar, U. S. S. R.
KRANTZ, F. A. .... University Farm, St. Paul, Minn.
KRAUS, E. J. .... University of Chicago, Chicago, Ill.
KRAYBILL, H. R. .... Purdue University, Lafayette, Ind.

LAGASSE, F. S. .... University of Delaware, Newark, Del.
LANTZ, H. L. .... Iowa State College, Ames, Iowa
LATIMER, L. P. .... University of New Hampshire, Durham, N. H.
LAURIE, ALEX .... Ohio State University, Columbus, Ohio
LAVOIE, J. H. .... Department of Agriculture, Quebec, Canada
LESLIE, W. R. .... Experiment Station, Morden, Manitoba
LEWIS, I. P. .... New Waterford, Ohio
LEWIS, MILTON T. .... Pennsylvania State College, State College, Pa.
LILLELAND, OMUND .... University Farm, Davis, Calif.
LIKHONOS, THEODORE ..... Institute of Applied Botany, Leningrad, Russia
LINCOLN, F. B. .... University of Californa, Berkeley, Calif.
LLOYD, J. W. .... University of Illinois, Urbana, Ill.
LOCKLIN, H. D. .... Western Washington Exp. Sta., Puyallup, Wash.
LOMBARD, P. M. .... U. S. Dept. Agr., Washington, D. C.
LOMMEL, W. E. .... Purdue University, Lafayette, Ind.
LONG, J. H. .... University of Missouri, Columbia, Mo.
LOOMIS, W. E. .... Iowa State College, Ames, Iowa
LOTT, RICHARD V. .... Colorado Agr. College, Ft. Collins, Colo.
LUCE, W. A. .... Wenatchee, Wash.
LUMSDEN, DAVID .... U. S. Dept. Agr., Washington, D. C.

MACDANIELS, L. H. .... Cornell University, Ithaca, N. Y.
MACGILLIVRAY, J. H. ...... Purdue University, Lafayette, Ind.
MACLENNAN, A. H. .... Agricultural College, Guelph, Ontario, Canada
MCCALL, THOS. M. .... N. W. Minn. School of Agriculture, Crookston, Minn.
MCCLINTOCK, J. A. .... Experiment Station, Knoxville, Tenn.
MCCOLLUM, JOHN P. .... Cornell University, Ithaca, N. Y.
MCCORMICK, A. C. .... Husum, Wash.
MCCOWN, MONROE .... Purdue University, Lafayette, Ind.
MCCUBBIN, E. N. .... University of West Virginia, Morgantown, W. Va.
MCCUE, C. A. .... Experiment Station, Newark, Del.
MCDONALD, R. C. .... Chilean Nitrate of Soda, Education Bureau, 1378 Nat'l Press Bldg., Washington, D. C.
MCGINTY, R. A. .... Agricultural College, Clemson, S. C.
MCHATTON, T. H. .... State College of Agriculture, Athens, Ga.
MCMUNN, R. L. .... University of Illinois, Urbana, Ill.
MCQUESTON, L. M. .... University Farm, Davis, Calif.
MACK, W. B. .... Pennsylvania State College, State College, Pa.
MACKINTOSH, R. S. .... University Farm, St. Paul, Minn.
MACOUN, W. T. .... Central Experimental Farm, Ottawa, Canada
MAGNESS, J. R. .... Washington State College, Pullman, Wash.
MAGRUDER, ROY .... Experiment Station, Wooster, Ohio
MAHONEY, C. H. .... Texas Techn. College, Lubbock, Tex.
MALHOTRA, RAM CHANDAR . University of Chicago, Chicago, Ill.
MANEY, T. J. .... Iowa Agricultural Experiment Station, Ames, Iowa

Marble, L. M. . . . . Canton, Pa.
Marsh, R. S. . . . . University of Illinois, Urbana, Ill.
Marshall, R. E. . . . . Michigan State College, East Lansing, Mich.
Martin, Jr., W. R. . . . . University of Missouri, Columbia, Mo.
Mason, A. F. . . . . University of Maryland, College Park, Md.
Medlock, O. C. . . . . Alabama Polytechnic Institute, Auburn, Ala.
Merrill, Grant . . . . U. S. Dept. Agr., Red Bluff, Calif.
Merrill, M. C. . . . . U. S. Dept. Agr., Washington, D. C.
Merrill, Samuel, Jr. . . . . 1285 Summit Ave., Pasadena, Calif.
Miki, Taiji . . . . Kanagawa-ken Noji-shikenjo (Agr. Exp. Station) Ofuna, near Yokohama City, Japan
Miller, J. C. . . . . Louisiana State Univ., Baton Rouge, La.
Mills, H. S. . . . . Box 358, Bristol, Pa.
Minns, L. A. . . . . Cornell University, Ithaca, N. Y.
Moore, J. G. . . . . University of Wisconsin, Madison, Wis.
Morris, H. F. . . . . Texas Substation No. 11, Nacogdoches, Tex.
Morris, O. M. . . . . Experiment Station, Pullman, Wash.
Morrow, E. B. . . . . North Carolina State College, Raleigh, N. C.
Mortensen, E. . . . . Substation No. 19, Winterhaven, Tex.
Motts, George N. . . . . Michigan State College, E. Lansing, Mich.
Motz, F. A. . . . . Experiment Station, Blacksburg, Va.
Mulford, F. L. . . . . U. S. Dept. Agr., Washington, D. C.
Murneek, A. E. . . . . University of Missouri, Columbia, Mo.
Musser, A. M. . . . . College of Agriculture, Clemson College, S. C.
Myers, C. E. . . . . Experiment Station, State College, Pa.

Nagai, Keizo . . . . Imperial Horticultural Experiment Station, Okitsu, Shizuoka-ken, Japan
Nebel, B. R. . . . . Experiment Station, Geneva, N. Y.
Nichols, H. E. . . . . Iowa State College, Ames, Iowa
Nightingale, G. F. . . . . . . Experiment Station, New Brunswick, N. J.
Nissley, C. H. . . . . Experiment Station, New Brunswick, N. J.
Nixon, Roy W. . . . . U. S. Dept. Agriculture, Washington, D. C.
Noro, Kimijiro . . . . Shizuoka-ken Agricultural Experiment Station, Toyudamura, near Shizuoka, Japan

Olney, A. J. . . . . Experiment Station, Lexington, Ky.
Oskamp, Joseph . . . . Cornell University, Ithaca, N. Y.
Overholser, E. L. . . . . University of California, Davis, Calif.
Overley, F. L. . . . . Wenatchee, Wash.

Paddock, W. . . . . Ohio State University, Columbus, Ohio
Page, E. M. . . . . 303 S. Seventh St., Corneli Seed Co., St. Louis, Mo.
Palmer, E. F. . . . . Vineland Station, Ontario, Canada
Palmer, R. C. . . . . Experiment Station, Summerland, B. C.
Park, J. E. . . . . Experiment Station, Rosthern, Saskatchewan
Parker, E. R. . . . . Citrus Experiment Station, Riverside, Calif.
Partridge, N. L. . . . . Box 133, Paw Paw, Mich.
Patterson, C. F. . . . . Saskatoon, Saskatchewan, Canada
Peacock, N. D. . . . . University of Tennessee, Knoxville, Tenn.
Pearson, Oscar H. . . . . . . University of California, Davis, Calif.
Peck, G. W. . . . . Cornell University, Ithaca, N. Y.
Pelton, W. C. . . . . University of Tennessee, Knoxville, Tenn.
Pentzer, W. T. . . . . U. S. Dept. Agr., Washington, D. C.
Peterson, Grace . . . . 9030 78th St., Woodhaven, N. Y.
Philp, G. L. . . . . University Farm, Davis, Calif.
Pickett, B. S. . . . . Iowa State College, Ames, Iowa
Pickett, W. F. . . . . Agricultural College, Manhattan, Kans.
Potter, G. F. . . . . Agricultural College, Durham, N. H.
Prather, E. M. . . . . University of Tennessee, Knoxville, Tenn.
Price, H. L. . . . . Experiment Station, Blacksburg, Va.
Pridham, Alfred . . . . Cornell University, Ithaca, N. Y.
Proebsting, E. L. . . . . University Farm, Davis, Calif.
Purmell, D. M. . . . . Nat'l Farm School, Farm School, Pa.

QUINN, J. T. .... University of Missouri, Columbia, Mo.

RALEIGH, G. J. .... 6122½ Kimbark Ave., Chicago, Ill.
RASMUSSEN, E. J. .... University of New Hampshire, Durham, N. H.
RAWL, E. H. .... Aiken, S. C.
REED, H. J. .... Experiment Station, Lafayette, Ind.
REHDER, ALFRED .... Arnold Arboretum, Jamaica Plain, Mass.
REIMER, F. C. .... Southern Oregon Branch Station, Talent, Ore.
REINECKE, O. S. H. .... Stellenbosch-Elsenburg College of Agriculture, Stellenbosch, Cape Provence, South Africa
RICHEY, H. W. .... Iowa State College, Ames, Iowa
ROBB, O. J. .... Vineland Station, Ontario, Canada
ROBBINS, W. REI .... Experiment Station, New Brunswick, N. J.
ROBBINS, W. W. .... University Farm, Davis, Calif.
ROBERTS, R. H. .... University of Wisconsin, Madison, Wis.
ROBERTSON, W. H. .... Department of Agriculture, Victoria, B. C.
ROLLINS, H. A. .... University of New Hampshire, Durham, N. H.
RUEF, J. U. .... Pennsylvania State College, State College, Pa.
RUTH, W. A. .... University of Illinois, Urbana, Ill.
RYERSON, K. A. .... U. S. Dept. Agriculture, Washington, D. C.
RYGG, LEONARD .... Oregon Agricultural College, Corvallis, Ore.

SANDSTEN, E. P. .... State Agricultural College, Fort Collins, Colo.
SAX, KARL .... Bussey Inst., Forest Hills, Mass.
SAYRE, C. B. .... Experiment Station, Geneva, N. Y.
SCHERMERHORN, L. C. ...... Experiment Station, New Brunswick, N. J.
SCHILLETTER, J. C. .... Iowa State College, Ames, Ia.
SCHMIDT, C. M. .... N. V. Potash Export, 19 W. 44th St., New York City
SCHRADER, A. L. .... University of Maryland, College Park, Md.
SCHUSTER, C. E. .... Agricultural College, Corvallis, Ore.
SEARS, F. C. .... Agricultural College, Amherst, Mass.
SEVY, H. P. .... Martinsburg, W. Va.
SHAW, J. K. .... Agricultural College, Amherst, Mass.
SHIMA, Y. .... Hokkaido Imperial University, Sapporo, Japan.
SHOEMAKER, D. N. .... U. S. Dept. Agr., Washington, D. C.
SHOEMAKER, J. S. .... Experiment Station, Wooster, Ohio
SITTON, B. G. .... 606 Court House, Shreveport, La.
SLATE, G. L. .... Experiment Station, Geneva, N. Y.
SMITH, EDWIN .... 208 Columbia St., Seattle, Wash.
SMITH, ORA .... A. & M. College, Stillwater, Okla.
SNYDER, ELMER .... 3930 Kerchoff Avenue, Fresno, Calif.
SNYDER, J. C. .... Iowa State College, Ames, Ia.
STAFFORD, I. B. .... Syracuse University, Syracuse, N. Y.
STAIR, E. C. .... Purdue University, Lafayette, Ind.
STANSEL, R. H. .... Substation No. 3, Angleton, Texas
STARRING, C. C. .... Montana State College of Agr., Bozeman, Mont.
STENE, A. E. .... Agricultural College, Kingston, R. I.
STOUT, A. B. .... New York Botanical Garden, New York City
STRONG, W. J. .... Vineland Station, Ontario, Canada
STUART, WILLIAM .... U. S. Dept. Agr., Washington, D. C.
STUCKEY, H. P. .... Experiment Station, Experiment, Ga.
SUDDS, R. H. .... Pennsylvania State College, State College, Pa.
SWINGLE, C. F. .... U. S. Dept. Agr., Washington, D. C.

TALBERT, T. J. .... University of Missouri, Columbia, Mo.
TAWSE, W. J. .... 750 Wilson Ave., Montreal, Can.
TAYLOR, R. H. .... 603 Plaza Building, Sacramento, Calif.
TAYLOR, R. W. .... Alabama Polytechnic Institute, Auburn, Ala.
THIES, W. H. .... Agricultural College, Amherst, Mass.
THOMAS, W. .... Pennsylvania State College, State College, Pa.
THOMPSON, H. C. .... Cornell University, Ithaca, N. Y.
TIEDJENS, V. A. .... 240 Beaver St., Waltham, Mass.
TOENJESS, WALTER .... Michigan State College, East Lansing, Mich.

TOKIMASA, DAVID........Cornell University, Ithaca, N. Y.
TRAUB, H. P.............Texas Experiment Station, College Station, Tex.
TUCKER, L. R............Kansas State Agric. College, Manhattan, Kan.
TUFTS, W. P.............University Farm, Davis, Calif.
TUKEY, H. B.............Experiment Station, Geneva, N. Y.
TUSSING, E. B...........Ohio State University, Columbus, Ohio

UNDERWOOD, F. O........Cornell University, Ithaca, N. Y.
UPSHALL, W. H...........Vineland Station, Ontario, Canada
URAKAWA, UNOSUKE......Kurumanichi, Saga, near Kyoto, Japan

VALLEAU, W. D...........University of Kentucky, Lexington, Ky.
VAN ALSTYNE, L. M.......Experiment Station, Geneva, N. Y.
VAN ESELTINE, G. P......Experiment Station, Geneva, N. Y.
VAN HAARLEM, J. R......Vineland Station, Ontario, Canada
VAN METER, R. A.........Agricultural College, Amherst, Mass.
VERNER, LIEF............University of Idaho, Moscow, Idaho
VIERHELLER, A. F........University of Maryland, College Park, Md.
VINSON, C. G.............Boyce Thompson Institute, Yonkers, N. Y.
VOLZ, E. C...............Iowa State College, Ames, Ia.

WALDO, G. F.............U. S. Dept. Agr., Washington, D. C.
WALKER, JOHN...........Dept. of Agriculture, Winnipeg, Canada
WARING, J. H............University of Maine, Orono, Me.
WATTS, R. L.............Experiment Station, State College, Pa.
WATTS, V. M.............University of Arkansas, Fayetteville, Ark.
WEBBER, H. J............Citrus Experiment Station, Riverside, Calif.
WEINBERGER, J. H.......University of Maryland, College Park, Md.
WELLINGTON, R..........Experiment Station, Geneva, N. Y.
WELLS, H. M.............Graham Hort. Exp. Sta., Grand Rapids, Mich.
WENTWORTH, S. W........Cornell University, Ithaca, N. Y.
WERNER, H. O...........University of Nebraska, Lincoln, Neb.
WESSELS, P. H...........Long Island Veg. Research Farm, Riverhead, N. Y.
WESTOVER, K. C..........West Virginia University, Morgantown, W. Va.
WHARTON, M. F..........University of Arizona, Tucson, Arizona
WHITEHOUSE, W. E.......University of Maryland, College Park, Md.
WIGGIN, W. W...........Experiment Station, Wooster, Ohio
WIGGANS, C. C..........University of Nebraska, Lincoln, Neb.
WILSON, A. L............Cornell University, Ithaca, N. Y.
WILSON, B. H............University Farm, St. Paul, Minn.
WILSON, R. M............Experiment Station, Morden, Manitoba
WINKLER, A. J...........University Farm, Davis, Calif.
WOOD, M. N.............409 Native Sons Hall, Sacramento, Calif.
WOODBURY, C. G.........National Canners' Association, Washington, D. C.
WOODROOF, J. G..........Experiment Station, Experiment, Ga.
WORK, PAUL..............Cornell University, Ithaca, N. Y.
WRIGHT, R. C............U. S. Dept. of Agr., Washington, D. C.

YATES, H. O.............New Camden Vacational School, Merchantville, N.J.
YEAGER, A. F............Agricultural College, Fargo, N. D.
YERGER, H. R............2626 N. Moreland Blvd., Cleveland, Ohio
YERKES, G. E............U. S. Dept. Agr., Washington, D. C.
YOCUM, W. W............University of Nebraska, Lincoln, Nebraska.

ZIMMERLEY, H. H.........Virginia Truck Experiment Station, Norfolk, Va.
ZIMMERMAN, P. W........Boyce Thompson Institute, Yonkers, N. Y.

INDEX

Date of Issue	Date of Issue	Date of Issue
11-4-66		
15-10-66		
20 Oct 1968		
14 SEP 1998		

Date of Issue	Date of Issue	Date of Issue
11-4-66		
15-10-66		
20 Oct 1968		
14 SEP 1998		